LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA24 | Birmingham Interchange and Chelmsley Wood

Flood risk assessment (WR-003-024)

Water resources

November 2013

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Appendix WR-003-024

Environmental topic:	Water resources and flood risk assessment	WR
Appendix name:	Flood risk assessment	003
Community forum area:	Birmingham Interchange and Chelmsley Wood	024

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise a number of parts. The first of these is a route-wide appendix (Volume 5: Appendix WR-001-000).

1.1.2 Additional specific appendices for each community forum area are also provided. For the Birmingham Interchange and Chelmsley Wood area (CFA24) these are:

- water resources assessment (Volume 5: Appendix WR-002-024);
- flood risk assessment (this appendix);
- a hydrology report for the River Blythe and associated tributaries (Volume 5: Appendix WR-004-016); and
- a hydraulic modelling report for Bayleys Brook (at Marsh Farm and Lavender Hall Lane), the River Blythe Bypass, Shadow Brook and Hollywell Brook (Volume 5: Appendix WR-004-018).

1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5 water resources map book.

1.2 Scope of this assessment

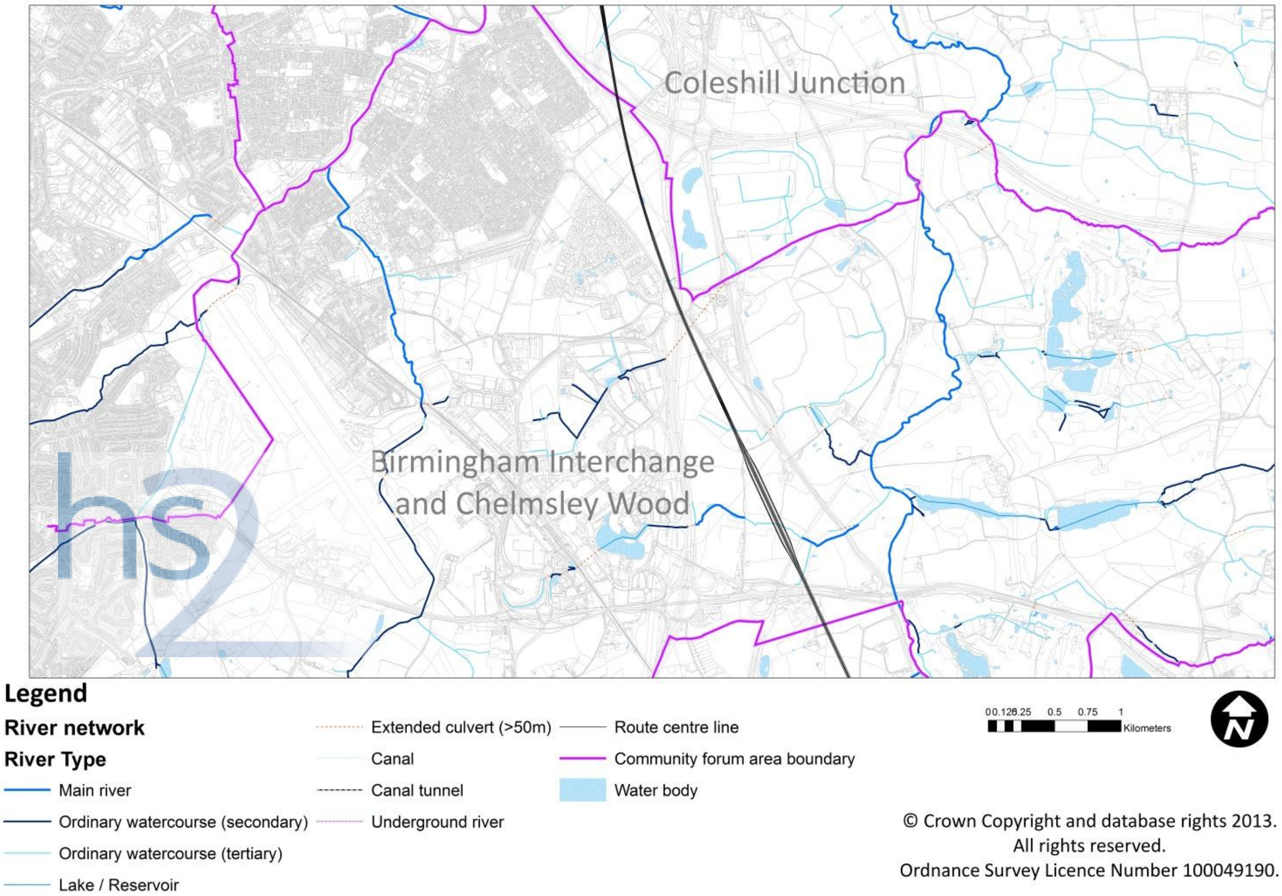
1.2.1 This flood risk assessment (FRA) considers the assessment of flood risk in the Birmingham Interchange and Chemsley Wood CFA. This FRA is based on the Proposed Scheme as shown in Map CT-06 (Volume 2, CFA24 Map Book). Its purpose is to document how flood risk has been assessed and managed at this stage of the project's development so as to inform the hybrid bill. It can be anticipated that the details of flood risk management will develop further as the project proceeds through later stages of design. The assessment has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF)[1], which aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it can occur without risk to the development or to third parties.

1.3 Location

1.3.1 This report focuses the Birmingham Interchange and Chelmsley Wood area. The area of consideration is shown in Figure 1 below.

[1] Department for Communities and Local Government (2012) *National Planning Policy Framework*

Figure 1: Birmingham Interchange station and Chemsley Wood



2 Flood risk assessment methodology

The aim of this FRA is to assess the risk of all forms of flooding to and from the development. A risk-based methodology has been adopted through the application of the source-pathway-receptor (SPR) model.

2.1 Source-pathway-receptor model

2.1.1 Flood risk is assessed using the source-pathway-receptor model. In this model, individual sources of flooding within the study area are identified. The primary source of flooding is rainfall, which is a direct source in the short-term (surface water flooding) and can lead to flooding from watercourses (river flooding) and overloaded man-made collection systems (sewer flooding) in the short or medium term. Stored rainfall, either naturally in below ground aquifers and natural lakes, or artificially in impounded reservoirs and canals, can lead to flooding when the storage capacity of the system is exceeded. A final source of flooding arises from tidal effects and storm surges caused by low pressure systems over the sea.

2.1.2 The identification of the flooding source and pathway is based on a review of local conditions and consideration of the effects of climate change (CC).

2.1.3 For there to be a risk of flooding at an individual receptor there must be a pathway linking it to the source of flooding. The pathways within the study area are assessed by reviewing national datasets that show the spatial distribution of flood risk. Taking this into account, the associated magnitude of risk is then categorised.

2.1.4 Receptors include people, properties, businesses, infrastructure, the built and the natural environment which is within the range of the flood source, and is connected to the source of flooding by a pathway. The Proposed Scheme includes all associated temporary and permanent infrastructure.

2.1.5 This FRA presents baseline (current day) flood risk and post-development flood risk as a result of the Proposed Scheme. Areas of interest are identified through comparison of the national spatial datasets with the design drawings. Where a risk is identified, mitigation is proposed in line with recommendations in the NPPF.

2.1.6 Existing development within the study area is identified using Ordnance Survey (OS) mapping information and a high level assessment has been undertaken to identify receptors that are within or in close proximity to an area of flood risk via pathways. The vulnerability of each receptor is classified using Table 2 of the NPPF Technical Guidance Document[2].

2.1.7 The assessment then considers the vulnerability of the receptor with reference to the flood risk category of the source using Table 3 of the NPPF Technical Guidance Document and assesses whether the Proposed Scheme has any potential to influence or alter the risk of flooding to each receptor. The Proposed Scheme is committed to ensuring that there is no adverse effect on the risk of flooding to third party receptors, and therefore, where such potential exists, mitigation is proposed based on further analysis.

[2] Department for Communities and Local Government, (2012), *National Planning Policy Framework Technical Guidance*.

2.1.8 The FRA has been written to demonstrate the relative change in flood risk as a result of the Proposed Scheme. Whilst all change in risk status is highlighted, the focus of this document is on the change in risk status to identified local receptors, particularly existing infrastructure.

2.2 Flood risk categories

2.2.1 The level of flood risk is categorised by assessing the design elements against the datasets for each source. A matrix showing the flood risk category associated with each flooding source is presented in Table 1.

Table 1: Flood risk category matrix for all flooding sources

Source of flooding	Flood risk category				
	No risk	Low	Medium	High	Very high
Watercourse[3]	-	Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Surface water / overland flow[4]	No FMfSW	FMfSW <0.3m for 1 in 200 year event	FMfSW >0.3m for 1 in 200 year event and FMfSW <0.3m for 1 in 30 year event	FMfSW >0.3m for 1 in 30 year event	-
Groundwater[5]	-	Very low-low	Moderate	High-very high	-
Drainage and sewer systems[6]	No sewer in vicinity of site	Surcharge point >20m from site and no pathways	Surcharge point within 20m of site and restricted pathways	Sewer network crosses site and pathways exist	-
Artificial sources[7]	Outside of inundation mapping / no pathway exists	Within inundation mapping / pathway exists	-	-	-

2.3 Exclusions and limitations

2.3.1 Temporary works have not been assessed unless they are of a significant scale compared with the post-construction scheme or are subject to or pose a significant flood risk or change in risk.

2.3.2 The assessment has been carried out in accordance with the requirements of the NPPF[8], which aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe without increasing flood risk elsewhere.

[3] River flood risk taken from the Environment Agency Flood Zone mapping or hydraulic modelling carried out for this FRA.

[4] Surface water flood risk taken from the Environment Agency Flood Maps for Surface Water (FMfSW).

[5] Groundwater flood risk taken from local flood risk assessment reports.

[6] Identified using the Severn Trent Water's assets network.

[7] Risk from reservoir flooding identified using the Environment Agency Reservoir Inundation mapping, canal flooding taken from identifying proximity of the Proposed Scheme to canals from Ordnance Survey mapping.

[8] Department for Communities and Local Government, (2012), *National Planning Policy Framework*.

2.3.3 No existing hydraulic models existed within this area, and a number of discrete hydraulic models were constructed. These are detailed in the accompanying hydraulic modelling report (Volume 5: Appendices WR-004-018). The model and flood extents should only be viewed in the context of assessing flood risk related to the Proposed Scheme.

2.3.4 This FRA (and accompanying appendices) will require updating as the design develops and a greater level of detailed data (e.g. topographical survey) become available.

3 Design criteria

3.1 Source of design criteria

3.1.1 This FRA has taken account of the following documents:

- NPPF;
- Highways Agency Design Manual for Roads and Bridges (1992)[9];
- National Sustainable Drainage Systems (SuDS) Working Group Interim Code of Practice (2009)[10]; and
- CIRIA Report C689 - Culvert Design and Operation Guide (2010)[11].

3.1.2 The key design criteria applied to the project are summarised below.

3.2 Summary of principal design criteria

Flood risk to third parties

3.2.2 The design has set out to avoid significant increases in flood risk to third parties, as a result of the Proposed Scheme up to and including the 1% Annual Exceedence Probability (AEP) flood event plus an appropriate allowance for climate change (cc) which has been abbreviated to 1% AEP+CC within this report.

Climate change

3.2.3 Climate change allowance is in accordance with NPPF.

3.2.4 Increases in peak rainfall intensity and peak river flow as a result of climate change have been allowed for as per the period 2085 to 2115 as defined in Table 5 of the Technical guidance to the NPPF and shown in Table 2 below.

Table 2: Appropriate climate change allowance figures for rainfall intensity and peak river flow (extract from Table 5 in Technical Guidance of the NPPF)

Parameter	1990 - 2025	2025 - 2055	2055 - 2085	2085 - 2115
Peak rainfall intensity.	+5%	+10%	+20%	+30%
Peak river flow.	+10%	+20%		

3.2.5 There is one departure to this, a 30% increase in flow in ungauged catchments has been used in order to account for uncertainty in flow calculations. This approach has been applied only when assessing culverts on small watercourses where no hydraulic modelling has been undertaken.

[9] Highways Agency, (1992), *Design Manual for Roads and Bridges for trunk roads.*

[10] National Sustainable Drainage Systems (SuDS) Working Group (2009), *SuDS Interim Code of Practice*

[11] CIRIA Report C689 (2010), *Culvert Design and Operation Guide*.

Freeboard at bridges

3.2.6 A minimum of 600mm freeboard above the 1% AEP+CC flood event has been allowed to the soffit of all bridges and viaducts. On main rivers, where possible, a freeboard of 1000mm has been allowed.

Freeboard at culverts

3.2.7 The freeboard provided between the 1% AEP+CC water level and the soffit of any proposed culvert is a minimum of 300mm for ordinary watercourses and 600mm for main rivers. The exception to this is where new structures are sized to match existing.

Flood protection to the Proposed Scheme rail infrastructure

3.2.8 The Proposed Scheme rail infrastructure (including the track drainage systems) will be designed to be protected against inundation in the 0.1% AEP flood event for both river and surface water flooding. This will be achieved through ensuring either a 1m between the rail level and the 0.1% AEP flood level, or by providing flood protection with a freeboard of at least 300mm above the 0.1% AEP flood level.

Attenuation of surface run-off

3.2.9 All drainage will be attenuated in order that peak surface run off from the Proposed Scheme in the events up to the 1% AEP+CC peak rainfall event is no greater than the existing current day baseline run-off under the same peak rainfall event.

4 Data sources

4.1.1 The following data sources have been referred to in the compilation of this document:

- Environment Agency web site; http://www.environment-agency.gov.uk/;
- reservoir flood mapping[12];
- generalised river flood mapping and flood zone mapping[13];
- Solihull Metropolitan Borough Council (SMBC) Level 1 Strategic Flood Risk Assessment (SFRA)[14];
- SMBC Preliminary Flood Risk Assessment (PFRA)[15];
- historic flooding records[16];
- flood map for surface water (FMfSW)[17];
- topographic survey (200mm grid resolution laser interferometry detection and ranging (LiDAR) survey, in digital terrain model and digital surface model format) and associated aerial photography;
- as built and historic drawings and land drainage records from Network Rail (NR), Birmingham City Council (BCC) & others;
- evidence gathered from site visits (including photographs);
- online photographic & mapping resources (Google maps, Bing maps etc.);
- Ordnance Survey 1: 10,000; 1:25,000 and 1:50,000 mapping;
- publicly available planning applications from recent developments within the area of interest;
- sewer network data from Severn Trent Water Plc (STW)[18];
- British Geological Survey (BGS) mapping;
- geotechnical desk studies; and
- Powell et al (2000)[19], Geology of the Birmingham area.

[12] Environment Agency, (2012), *Lakes and reservoirs GIS layer*

[13] Environment Agency, (2012), *Flood zone mapping GIS layer*

[14] Halcrow, (2008), *Solihull Metropolitan Borough Council Level 1 Strategic Flood Risk Assessment*

[15] WSP, (2011), *Solihull Metropolitan Borough Council Preliminary Flood Risk Assessment*

[16] Environment Agency, (2012), *Midlands Historical 1992 and 2007 flood event GIS layers*

[17] Environment Agency, (2012), *Midlands Flood Map for Surface water GIS layers*

[18] Severn Trent Water, (2012), *Utilities GIS Data*

[19] Powell, JH, Glover, BW, and Waters, CN. (2000), *Geology of the Birmingham area. Memoir of the British Geological Survey, Sheet 168 (England and Wales)*

5 The proposed development

5.1.1 The Proposed Scheme through this area is approximately 4.35km in length (see Maps CT-06-105b to CT-06-107-R1, Volume 2, CFA24 Map Book). The route commences south-east of the A45 Coventry Road in Hampton-in-Arden and proceeds north-west into a triangular site with the A452 Chester Road to the east, the M42, Birmingham Airport and NEC to the west and the A45 Coventry Road to the south.

5.1.2 Within the triangular site a new station and associated infrastructure, known as Birmingham Interchange station, will be constructed together with a people mover and People Mover Depot. The people mover will provide connectivity between this new station, the NEC, Birmingham International station and Birmingham Airport.

5.1.3 Leaving the triangular site, the route will continue north-west, crossing over the M42 on viaduct, with Coleshill and Bannerly Pools SSSI to the north-east and Birmingham Business Park to the south-west. The route will then continue over the M6 on viaduct with Chelmsley Wood residential estate located to the south-west. The route will leave this area at the administrative boundary between SMBC and North Warwickshire Borough Council, in close proximity to where the M42 intersects with the M6.

5.2 Design elements

5.2.1 To facilitate the Proposed Scheme the following design elements are required:

- high speed rail lines;
- overhead electrification gantries;
- signals;
- embanked sections of the route and side road diversions;
- sections in cutting of the route and side road diversions;
- viaducts and overbridges spanning urban areas, rural land, highways, railways, watercourses and canals;
- bridges under existing urban areas, rail and highway infrastructure;
- flood relief culverts;
- culverts for existing watercourses;
- river diversions;
- drainage infrastructure;
- Birmingham Interchange station; and
- an elevated people mover.

5.2.2 Within the study area the following elements have direct relevance to the assessment of flood risk:

- modifications to Stonebridge Island adjacent to the River Blythe;
- A452 (T) diversion with culvert crossing of Hollywell Brook;
- diversion of Hollywell Brook and associated bridge crossing;

- Birmingham Interchange station, including an elevated people mover; and
- surface water drainage.

6 Existing flood risk

6.1 River Flood risk

6.1.1 River flood risk within the study area is dictated by the risk posed by the River Blythe catchment, and in particular, it's tributary Hollywell Brook, together with smaller unnamed tributaries.

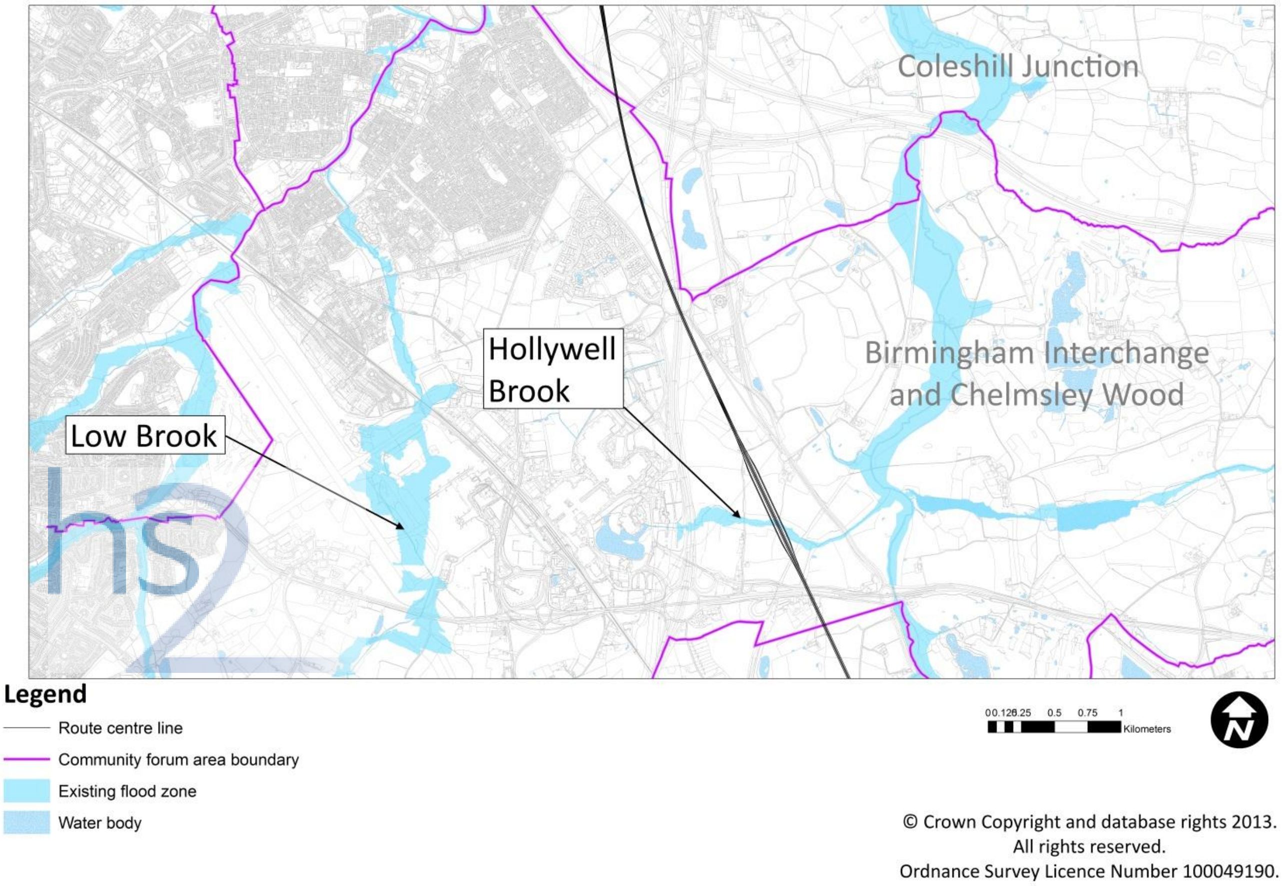
6.2 River Blythe catchment

6.2.1 The River Blythe is a major tributary of the River Tame and drains parts of North Warwickshire, Solihull and the surrounding rural areas. It has a total catchment of 131km^2 upstream of the River Blythe viaduct. It is a main river and as such regulatory control is with the Environment Agency, although riparian landowners do have a responsibilities to manage the river where it passes through their land and are restricted on what activities they can perform within or adjacent to the river without consent from the Environment Agency.

6.2.2 The river reach in proximity to the Proposed Scheme is designated as a site of special scientific interest (SSSI). Much of the River Blythe's catchment is within the Balsall Common and Hampton-in-Arden area (CFA23) and has been detailed within the accompanying flood risk assessment (Volume 5: Appendix WR-03-023). Hollywell Brook which forms part of this study is also a tributary of the River Blythe.

6.2.3 In order to establish the existing flood risk posed by the River Blythe catchment to the land located along and adjacent to the route, reference has initially been made to the existing flood zone mapping available from the Environment Agency. This is shown in Figure 2.

Figure 2: Existing flood zone mapping for the River Blythe and tributaries (Environment Agency, 2012)[13]



6.2.4 The flood zone mapping indicates that a section of the route and associated infrastructure within the study area may be at high risk from inundation from tributaries of the River Blythe, as it is partly located in flood risk zone 3a. This indicates that it is at high risk from inundation (during a flood event with a 1% AEP or more frequent).

6.2.5 In order to fully understand the existing risk posed by the river catchment and to be able to evaluate the impact of the Proposed Scheme on the hydraulic behaviour of the River Blythe catchment a one dimensional (1D) steady (non-time dependent) state model was created for Hollywell Brook. The Environment Agency does not have an existing model of the Blythe catchment in the study area.

6.2.6 A hydraulic model was created for the Hollywell Brook crossing as the 1% AEP+CC exceeded $3m^3/s$.

6.2.7 The details of the activities undertaken to produce a baseline river hydraulic model are documented in the modelling report found in Volume 5: Appendix WR-004-018.

6.2.8 The hydraulic model has been used to determine water levels along the sections of river channel and on the floodplain for the following flood events in the baseline state:

- 50% AEP;
- 20% AEP;
- 10% AEP;

- 5% AEP;
- 2% AEP;
- 1% AEP;
- 1% AEP +CC; and
- 0.1% AEP.

6.2.9 The Proposed Scheme crossings of Hollywell Brook are described in Section 6.3 along with the flooding extents and levels derived from the baseline models.

6.2.10 Simplified culvert calculations based on CIRIA Report C689 (see Section 3.1) were used to assess the post development flood risk impact of smaller watercourses.

6.3 Hollywell Brook

6.3.1 The Hollywell Brook is a tributary of the River Blythe and is a main river to the east (downstream) of the M42. The lower reach of the brook flows in a west to east direction and confluences with the River Blythe east of A452 Chester Road. The catchment area is approximately 6km^2 and is semi-rural while also receiving drainage from the NEC. The upstream reach of the brook is attenuated by a man-made retention lake, Pendigo Lake, constructed as part of the NEC drainage network. The hydrological assessment used in the hydraulic modelling of Hollywell Brook does not take account of retention of flows within Pendigo Lake and may therefore over estimate peak flows.

6.3.2 The Proposed Scheme will cross Hollywell Brook (Hollywell Brook underbridge) to the east of the NEC, between the A452 Chester Road and Middle Bickenhill Lane. The Proposed Scheme will interact with Hollywell Brook between Middle Bickenhill Lane and the dismantled Hampton-in-Arden to Shustoke line (see Figure 3) and incorporates the route, Birmingham Interchange station and associated car parks and infrastructure. There will be one crossing of the Hollywell Brook upstream of Middle Bickenhill Lane with an overland people mover. There is the dismantled Hampton-in-Arden to Shustoke line embankment spanning Hollywell Brook immediately downstream of the Proposed Scheme. The culvert which conveys the brook beneath the embankment introduces a significant flow restriction and attenuates flow in the upstream reach, in the vicinity of the Proposed Scheme's crossing.

6.3.3 Due to the watercourse’s relatively linear, narrow, uniform floodplain a 1D steady state model (HEC-RAS) was considered sufficient for assessing peak water levels for the range of flood events for both the baseline and post development scenarios. The details of the model build are discussed in the modelling report included in Volume 5: Appendix WR-004-018.

6.3.4 A preliminary hydrological investigation has been undertaken in order to estimate the magnitude of flows generated by the catchment up to a point a short distance downstream the crossing point of the Proposed Scheme. The hydrology report is included in Volume 5: Appendix WR-004-016.

6.3.5 The flows taken forward to the hydraulic analysis are shown in Table 3.

Table 3: Hollywell Brook peak flow calculation results using ReFH

AEP	Flow (m^3/s)
50%	1.59
20%	2.10
10%	2.5
5%	2.92
2%	3.55
1.33%	3.88
100	4.13
1% plus 20%	4.96
1% plus 30%	5.37
0.1%	7.40

6.3.6 The flooding extents for the 5% AEP and the 1% AEP plus CC event are shown in Maps WR-05 and WR-06 (Volume 5, Map Book Water resources). The flood extents for a range of flood events are shown in Figure 3.

Figure 3: Flooding extents for the 1% AEP+ CC for Hollywell Brook from baseline modelling

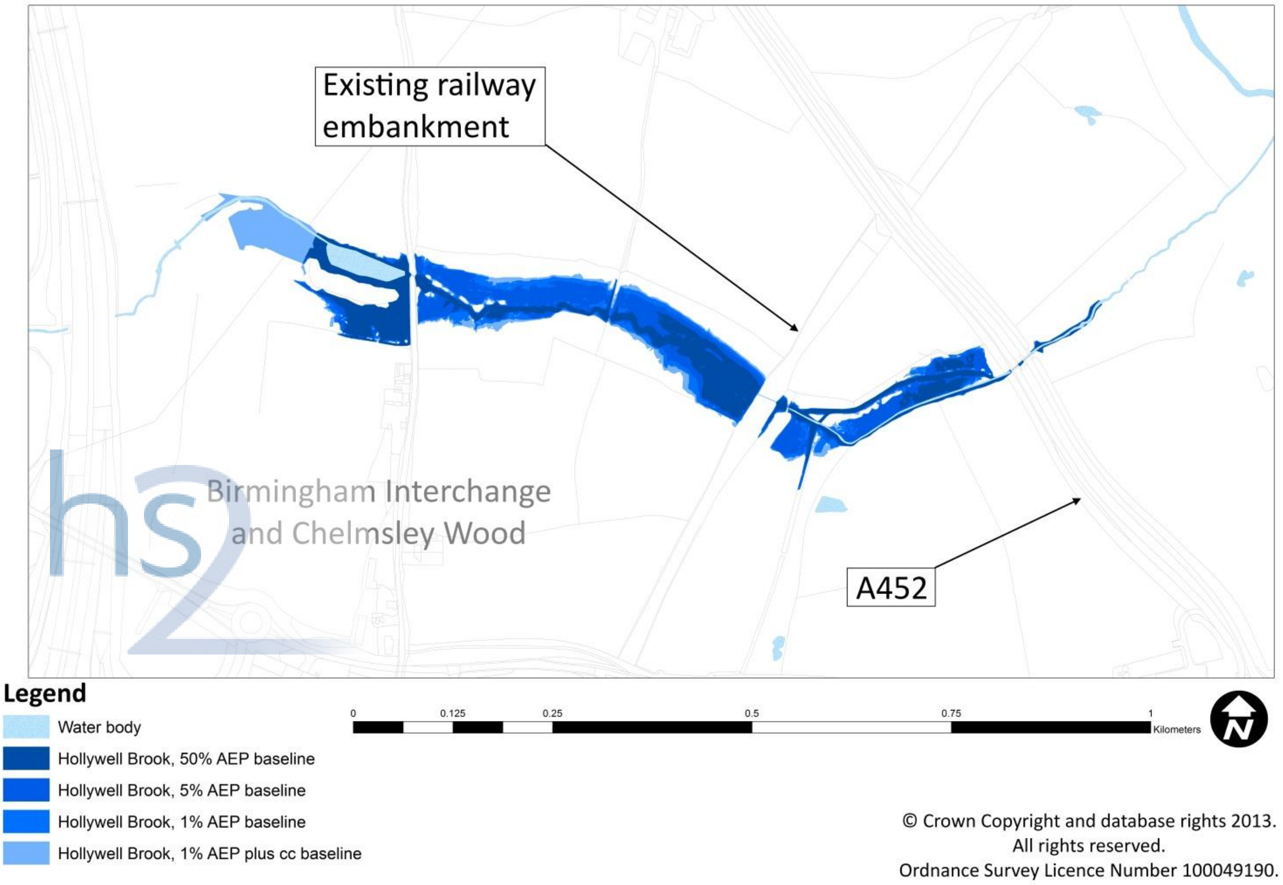


Table 4: Hollywell Brook baseline flood levels (for cross-section locations see Volume 5: Appendix WR-004-018)

	AEP					
Proposed Scheme feature	**50%**	**10%**	**5%**	**2%**	**1%**	**1% plus CC**
A452 Chester Road diversion ~70m upstream of A452 Chester Road (model cross-section 7)	83.761	83.933	84.001	84.096	84.182	84.288
~60m downstream of Proposed Scheme (model cross-section 12)	85.003	85.23	85.333	85.486	85.625	85.825
~70m upstream of Proposed Scheme crossing (model cross-section 15)	85.562	85.672	85.698	85.727	85.776	85.898
~ 65m downstream of Middle Bickenhill Lane (model cross-section 17)	85.893	85.989	86.021	86.064	86.092	86.137
People mover crossing and Birmingham Interchange station car parks (model cross-section 20)	86.725	86.778	86.789	86.815	86.826	86.856

6.3.7 The results of the baseline modelling confirm that the location of the Proposed Scheme is affected by river flood risk. The diversion of the A452 Chester Road will also be affected by flood risk from the Hollywell Brook.

6.3.8 The key flood receptors in the vicinity of the development are agricultural land located downstream of the A452 Chester Road and a wooded area located downstream of the dismantled Hampton-in-Arden to Shustoke line embankment. The A452 Chester Road is not predicted to flood for the baseline condition.

6.3.9 Land upstream of the dismantled Hampton-in-Arden to Shustoke line embankment is predicted to flood to a greater extent than the natural floodplain due to the attenuation effect of the culvert and embankment which clearly restrict the downstream flow even during higher probability flood events.

6.3.10 There are no dwellings within or near to the 1% AEP+CC floodplain.

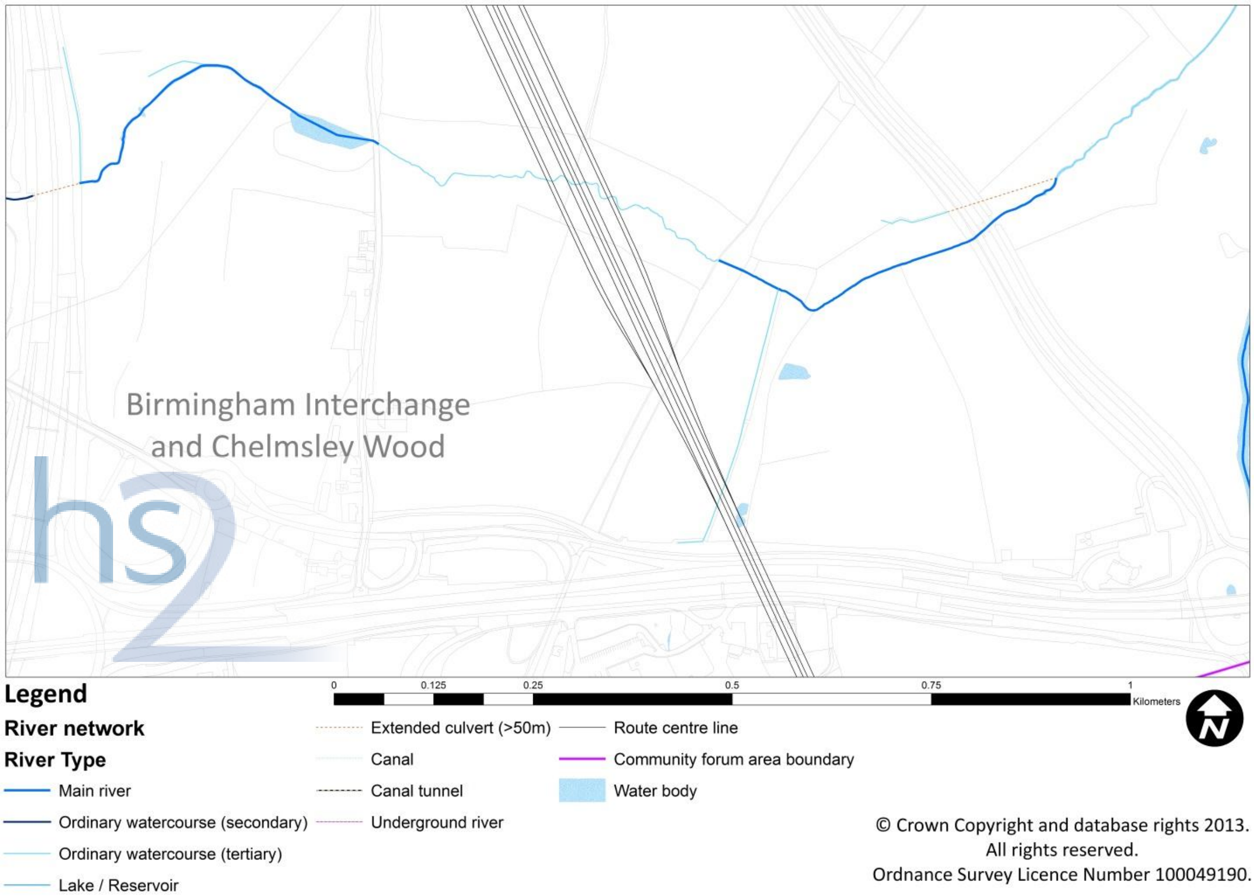
Other tributaries

6.3.11 There are two minor watercourses that also cross the route. The locations of these watercourses are shown in Figure 4 and Figure 5.

6.3.12 The first unnamed watercourse is a tributary of the Hollywell Brook and drains a predominantly rural catchment of 2.9km^2 and is shown in Figure 4. There is an existing culvert located upstream of the Proposed Scheme crossing which will pass beneath the A45 Coventry Road. There is no floodplain identified on the Environment Agency's flood mapping.

6.3.13 A preliminary hydrological investigation has been undertaken in order to understand the magnitude of flows generated by the catchment up to a point a short distance downstream the Proposed Scheme crossing point. The hydrology report is included in Volume 5: Appendix WR-004-016.

Figure 4: Watercourse crossing to Hollywell Brook



6.3.14 The flows taken forward to the hydraulic analysis are shown in Table 5.

Table 5: Peak flow calculation results using ReFH

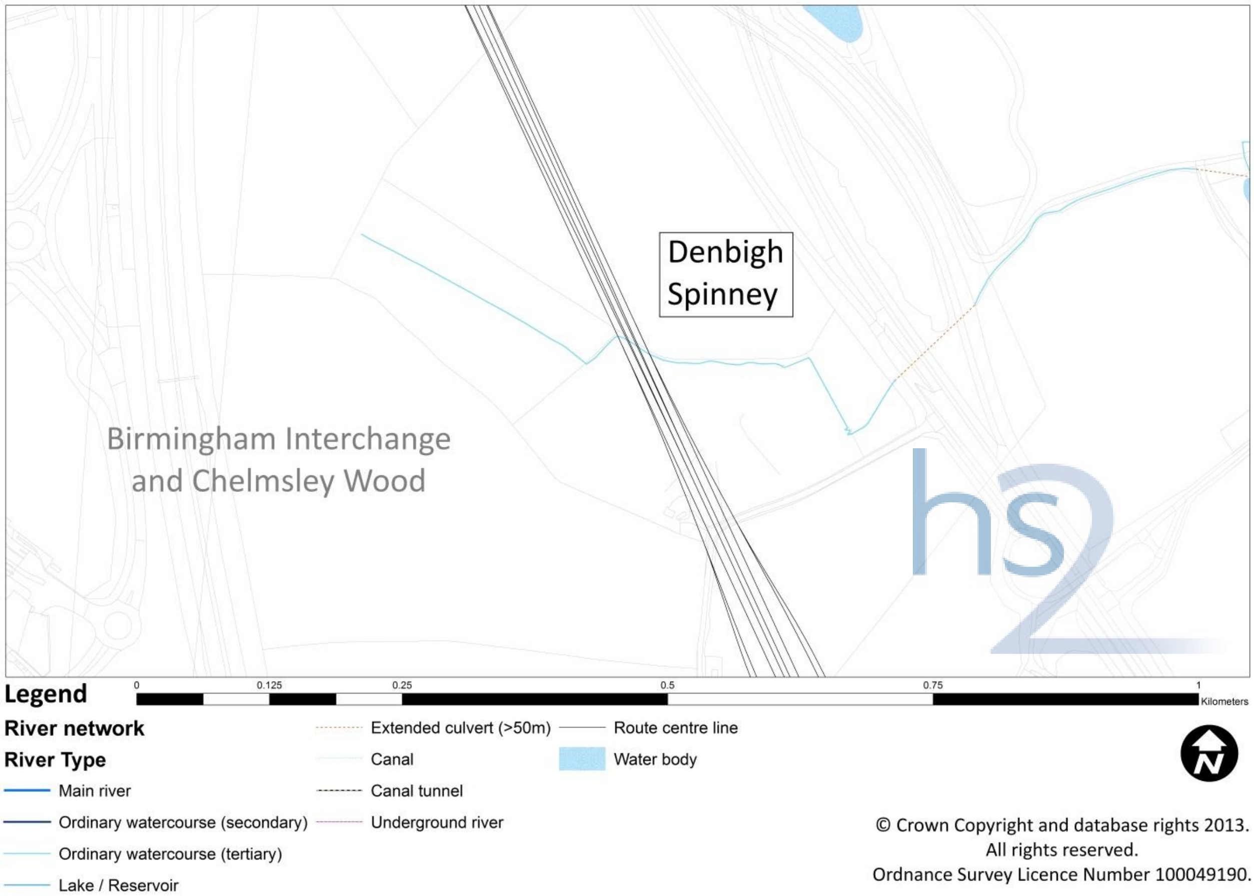
AEP	Flow (m^3/s)
50%	0.16
20%	0.21
10%	0.26
5%	0.31
2%	0.38
1.33%	0.42
1%	0.45
1% plus 20%	0.54
1% plus 30%	0.59

AEP	Flow (m^3/s)
0.1%	0.85

6.3.15 A second unnamed watercourse is tributary of the River Blythe and drains a predominantly rural catchment of $0.9km^2$ is shown in Figure 5. There is an existing culvert located downstream of the Proposed Scheme crossing which carries the watercourse beneath the A446 Stonebridge Road/A452 Chester Road junction, Fishpool Lane and the dismantled Hampton-in-Arden to Shustoke line embankment. The watercourse appears to have been heavily modified to avoid previous development.

6.3.16 A preliminary hydrological investigation has been undertaken in order to understand the magnitude of flows generated by the catchment up to a point a short distance downstream the Proposed Scheme's crossing point. The hydrology report is included in Volume 5: Appendix WR-004-016.

Figure 5: Watercourse crossing to Denbigh Spinney



6.3.17 The flows taken forward to the hydraulic analysis are shown in Table 6.

Table 6: Peak flow calculation results using ReFH

AEP	Flow (m^3/s)
50%	0.11
20%	0.15
10%	0.18
5%	0.21
2%	0.28
1.33%	0.31
1%	0.33
1% plus 20%	0.39
1% plus 30%	0.43
0.1%	0.68

6.3.18 Detailed baseline flood mapping has not been established for these smaller watercourses but the potential impact of the development on flood risk and the risk to the development have been assessed using the culvert analysis method described in CIRIA Report C689. The flood risk management of these smaller watercourses is discussed in Section 8.

6.4 Surface water and sewerage flood risk

6.4.1 This section is an examination of the existing flood risk posed by rainfall hitting the ground surface. This is often referred to as surface water. In this section it is examined in two ways (i) in terms of the risk posed in the event of failure or exceedance of existing drainage systems, and (ii) in terms of examining the pathways exploited by water flowing over the ground.

6.4.2 Surface water can manifest itself as ponding or surface water flow when flows cannot enter a drainage system because the capacity is exceeded. Flooding can also occur when the surface water flow pathway reaches a receptor. This is also referred to as surface water flood risk.

6.4.3 Surface water flood risk is assessed by examining existing surface water flow routes and reviewing the potential risk posed by the existing systems in place designed to manage surface water.

Drainage systems

6.4.4 Within this study area, surface water is generally collected in rural open drainage channel networks unless locally intercepted by highway drainage or other development drainage systems.

6.4.5 Due to the semi-rural location, there are only localised sewer networks through this area. The majority of the drainage systems are the responsibility of Severn Trent Water or SMBC for highway drainage.

Route wide within CFA24

6.4.6 The existing public sewer networks owned by Severn Trent Water within the catchments affected have been reviewed and there will be no significant interactions between the Proposed Scheme and the existing sewerage network within the study area. Highway drainage and some private drainage may be encountered along the route but no records were available to inform this flood risk assessment.

Surface water flow flood risk

6.4.7 The assessment of the existing flood risk posed by existing surface water flow routes has been based on the following:

- an investigation of existing topography using contours generated from LiDAR survey data;
- examining the Environment Agency's surface water flood mapping FMfSW; and
- documenting any reported instances of flooding from the SMBC's SFRA and PFRA.

6.4.8 The route will cross a number of natural drainage paths which form valleys in the topography. Consequently local surface water flow routes are towards the Proposed Scheme in number of localities. The general direction of surface water flow is shown in Annex A of this report. These plans do not take into account the influence of infrastructure such as roads where any surface water flow could be intercepted by artificial drainage.

6.4.9 The Environment Agency's surface water flood mapping has also been examined and is shown in Map WR-01-041 (Volume 5, Map Book Water resources). These have been compiled by the Environment Agency using a simple ground model to indicate where surface water would be expected to flow or pond during the 0.5% AEP rainfall event. The mapping provides an indication of flooding greater than 0.1m depth and flooding greater than 0.3m deep. This data does have limitations but illustrates areas that may be at risk and where a more detailed study may be required as the design develops.

6.4.10 The data set primarily identifies flooding along watercourse floodplains which is addressed separately as part of the river flood risk assessment. However, there are a number of significant features that are expected to accumulate significant depths of water during rainfall events. The data set has been used to identify the following locations along or in close proximity of the Proposed Scheme where surface water flow may be a flood risk consideration:

- ponding of water behind the embanked A45 Coventry Road (south of the proposed Birmingham Interchange station);
- ponding of water in an area between Packington Lane / A452 Chester Road and the M42; and
- flow of water along the M42 corridor close to the Proposed Scheme crossing.

6.4.11 Two additional separate areas are located at the two M42 road crossings in this study area, one located to the south-east of the Birmingham Business Park, and the other west of Brickhill Street Farm. These areas are associated with low lying sections of road rather than any waterbodies. These areas are categorised as low and medium flood risk in line with the flood risk category matrix. There are additional isolated areas both to the east and west of the route, within 1km. These are located immediately west of Pool Wood, east of the A452 Chester Road just north of the Birmingham Business Park, west of the M6 between Pool Wood and Brickhill Street Farm, and south west of the northern M42 road crossing in this study area. These areas are classed as low, medium and high flood risk.

Birmingham Interchange station and people mover

6.4.12 Birmingham Interchange station will occupy a significant development area and the surface water flood risk associated with this section of the development is discussed separately from the remainder of the linear route.

6.4.13 Birmingham Interchange station will be located within the triangle of land bounded by the A45 Coventry Road to the south, the A452 Chester Road to the east and the M42 to the west and comprises of mainly farm land. The only buildings within the rural site are Park Farm and Common Farm located along the A452 Chester Road and a few properties along Middle Bickenhill Lane, which is the only road within the site. The route will cross the site on roughly a north south axis and the proposed Birmingham Interchange station is located centrally over the route and just north of Hollywell Brook.

6.4.14 The site comprises of a southern valley along Hollywell Brook and a northern generally flat plateau. The bed of Hollywell Brook is at a level of approximately +85m above ordnance datum (mAOD) and rises on the southern side to +95m to +100m AOD along the A45 Coventry Road and rises more steeply on the northern side to the plateau which lies between +95m to +100m AOD.

6.4.15 The southern area of the triangle drains to the Hollywell Brook, which enters the site from the NEC under the M42 in culvert, crosses the site parallel to the A45 Coventry Road and exits under the A452 Chester Road in a box culvert under each carriageway. Hollywell Brook is classified as a main river and receives upstream flows from part of Birmingham Airport and the whole of the NEC. Flows from these areas are attenuated in Pendigo Lake within the NEC which includes a complex flow control on its exit.

6.4.16 The southern area of the triangle site drains naturally down moderate topographic slopes to the Hollywell Brook. The northern area of the site drains naturally along shallow slopes to an unnamed brook which exits the site under the A452 Chester Road.

6.4.17 The triangle is a rural area with no existing public foul or surface water sewers. The nearest foul sewer connections are offsite at the National Motorcycle Museum by junction 4 of the M42 to the south and Birmingham Business Park to the north of the triangle site.

6.4.18 The surrounding main roads and M42 include highway drainage which outfall separately to local watercourses.

6.4.19 The route of the people mover will cross over existing predominantly hard surfaced areas at Birmingham Airport, Birmingham International station and the NEC, over Pendigo Lake and the M42, and across agricultural land and Hollywell Brook floodplain within the Birmingham Interchange station triangle.

6.5 Groundwater

6.5.1 Groundwater flood risk within the study area has been qualitatively assessed based on hazard identification and evaluation using the conceptual understanding of the ground conditions along the route as informed by geotechnical desk studies. The assessment of baseline groundwater flood risk is based on the presence or otherwise of an aquifer and the relative depth to groundwater level, as well as historical information on the occurrence of groundwater flooding incidents.

Baseline Description

6.5.2 The following sections present details of the ground conditions along the route within the study area and a literature review of historical groundwater flooding incidents from the SMBC Strategic Flood Risk Assessments.

Geology

6.5.3 The solid and superficial geology of the route corridor is presented below.

Solid Geology

6.5.4 The geological structure of the study area comprises Triassic deposits (Mercia Mudstone Group) forming part of the Knowle Basin, overlain by glacial and alluvial superficial deposits.

6.5.5 The Arden Sandstone, which includes beds of sandstone and mudstone, is present beneath the NEC/proposed people mover site.

Superficial Geology

6.5.6 In terms of superficial geology, the area underlying the Proposed Scheme within the study area is characterised by widespread glacial deposits dating from the Mid Pleistocene. These comprise Glaciofluviual deposits, Glaciolacustrine deposits and Glacial Till.

6.5.7 The Glaciofluvial deposits are generally sands and gravels, forming large plateaux. These are locally up to approximately 25m thick and have been quarried in the area. One significant area extents north of Birmingham Interchange station and extends beyond the study area at the M42 motorway underbridge.

6.5.8 Glaciolacustrine deposits, typically laminated clays and silts, are only mapped near Birmingham Business Park from the M42 underbridge northward. Whilst this is mostly outside the extents of the study area, Glaciolacustrine clays were also identified in some historic boreholes as noted in the following sections.

6.5.9 A thin covering of Head deposits is present on valley sides and slopes in the area, locally up to several metres thick. This is not shown on the BGS mapping but was identified in a number of the historic boreholes.

6.5.10 Narrow channels of Alluvium are present close to stream courses, overlying the glacial deposits.

6.5.11 Made Ground occurs at various locations throughout the route within the study area. It is mainly associated with highway earthworks and landscaping around developments, but has also been used for land raise and backfill to gravel pits.

6.5.12 Superficial glacial deposits resulting from several phases of glaciations during the Anglian and probably Wolstonian glacial periods, between approximately 400,000 and 200,000 years ago, are present beneath much of the route within the study area. Due to erosion after the last glacial phase, the cover of glacial material is discontinuous in places. During the last (Devensian) glacial period, that finished approximately 10,000 years ago, glacial ice did not reach this area, but periglacial permafrost conditions prevailed across the region.

6.5.13 Most of the glacial deposits beneath the route within the study area are sands and gravels formed during a glacial retreat phase by southward flowing melt water. These glacial sands and gravels form an extensive, but now dissected spread, beneath the axis of the River Blythe valley and form a significant local aggregate resource. They vary widely in lithology from fine grained silty sands to coarse poorly sorted boulder gravel. They are generally 5m-10m thick but can be up to 15m thick.

Hydrogeology

6.5.14 The strata have been classified using the Environment Agency aquifer classification framework[20].which is consistent with the EU Water Framework Directive (2000) [21]. The aquifer designations for each stratum are summarised in Table 7.

Table 7: Summary of aquifer designations for geological units within the study area

Geological unit	Aquifer designation
Alluvium	Secondary A
Head	Secondary undifferentiated
River Terrace Deposits	Secondary A
Glacial till	Unproductive
Glaciofluvial Deposits and Glacioacustrine Deposits	Secondary A
Mercia Mudstone	Secondary B
Arden Sandstone	Secondary A

[20] Environment Agency, (2013), *Aquifer Classification Framework [online], [Accessed 05-02-2013]. Available from: http://www.environment-agency.gov.uk/homeandleisure/117020.aspx*

[21] Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy, European Council

6.5.15 The aquifer designation is as follows:

- Secondary A aquifers are considered to consist of variable permeability layers capable of supporting water supplies at a local scale; and
- Secondary B aquifers are predominantly of lower permeability and may locally store groundwater due to localised features such as thin fissures, thin permeable horizons and weathering.

6.5.16 No groundwater source protection zones (SPZ) are located along or within 250m of the route as shown on Map WR-02-24 (Volume 5, Map Book Water resources).

6.5.17 Coleshill and Bannerly Pools SSSI is present approximately 270m east of the route near the M42 underbridge to the northern end of the Birmingham Interchange and Chelmsley Wood area.

Historical occurrence of groundwater flooding events

6.5.18 SMBC's SFRA identifies a number of historical flooding events due to a combination of surface water and river flooding. However there are no known problems with flooding from groundwater within 1km of the Proposed Scheme within the Solihull Metropolitan Borough.

Current groundwater flood risk

6.5.19 The superficial deposits along the route are mainly free draining sands and gravels. The River Terrace deposits, Glaciofluvial deposits and Arden Sandstone are designated as Secondary A aquifers.

6.5.20 Groundwater strikes from available borehole logs and monitoring instrumentation show that water strikes occur in the area of the Glaciofluvial outcrop which is present north of the Hollywell Brook. Near surface water levels can also be expected in the River Blythe floodplain east of the route.

6.5.21 Although there are areas of permeable superficial deposits associated with rivers and watercourses where relatively shallow groundwater levels are expected, the current level of groundwater flood risk is considered low, this is supported by information that there are no reported historical groundwater flooding incidents on record.

6.6 Artificial sources/infrastructure failure

6.6.1 Artificial sources of flood risk describe a mechanism whereby the source of flooding would be failure of infrastructure used to impound (reservoir), retain (dam) or convey water (water pipeline).

6.6.2 In the Birmingham Interchange and Chelmsley Wood area flooding is a realistic possibility from the failure of the following infrastructure:

- surface water sewerage systems;
- foul water sewerage systems;
- water supply pipe networks; and

- reservoir failure.

6.6.3 The nearest canal to the Proposed Scheme within the Birmingham Interchange and Chemlsley Wood area is the Grand Union Canal which follows a general north to south route some 3.6km to the west of the route centre line at its closest point. The canal is predominantly in cutting or grade and is not considered to pose a significant flood risk to the Proposed Scheme.

Water supply network

6.6.4 Water mains and water distribution infrastructure are a potential source of flood risk in the event of a failure. This section identifies significant water mains within the network and their position relative to the Proposed Scheme for the baseline condition.

6.6.5 Significance of the water main is based on diameter and pressure. It is assumed that the majority of small diameter pipes within the network are of low risk as the rate at which water escapes will be low. Where the risk is not considered to be low the utility is presented in Figure 6 and Figure 7.

Figure 6: Coventry Road water mains

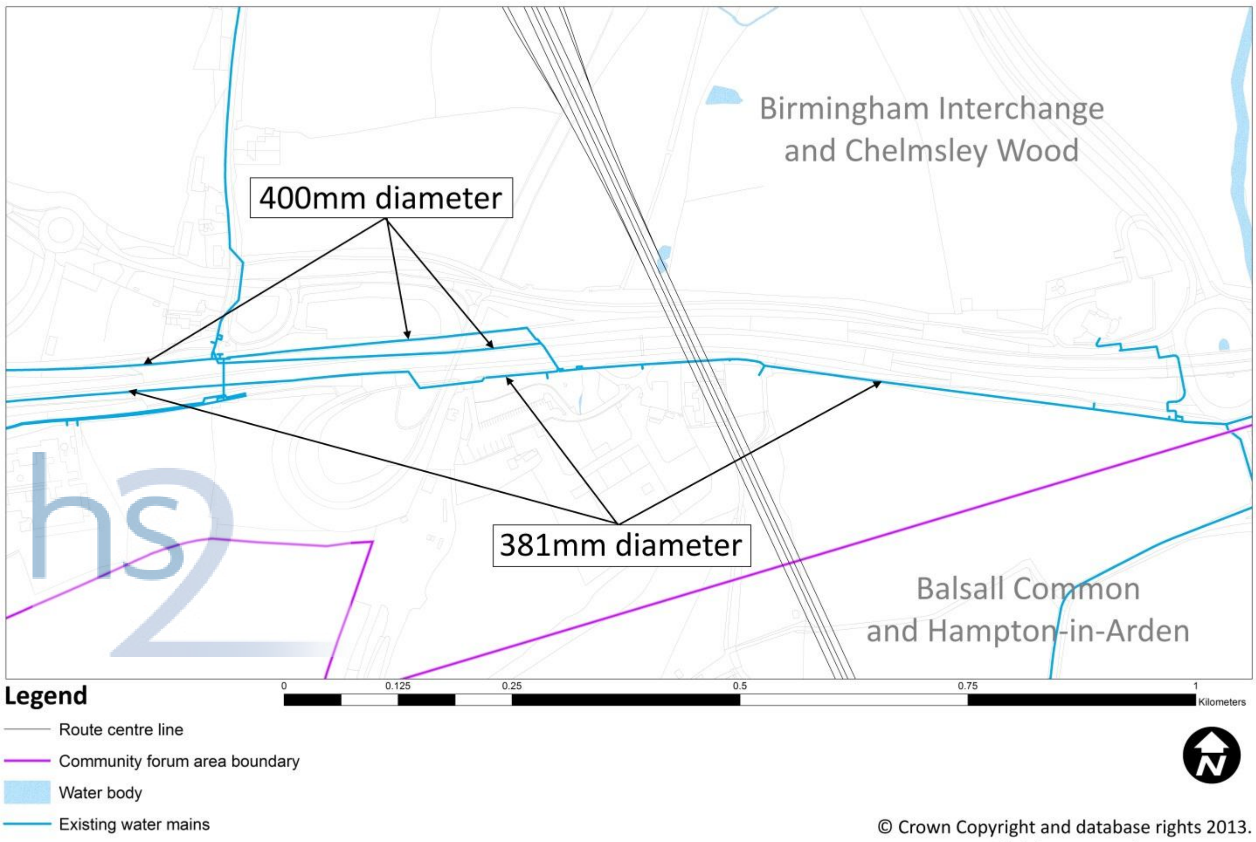
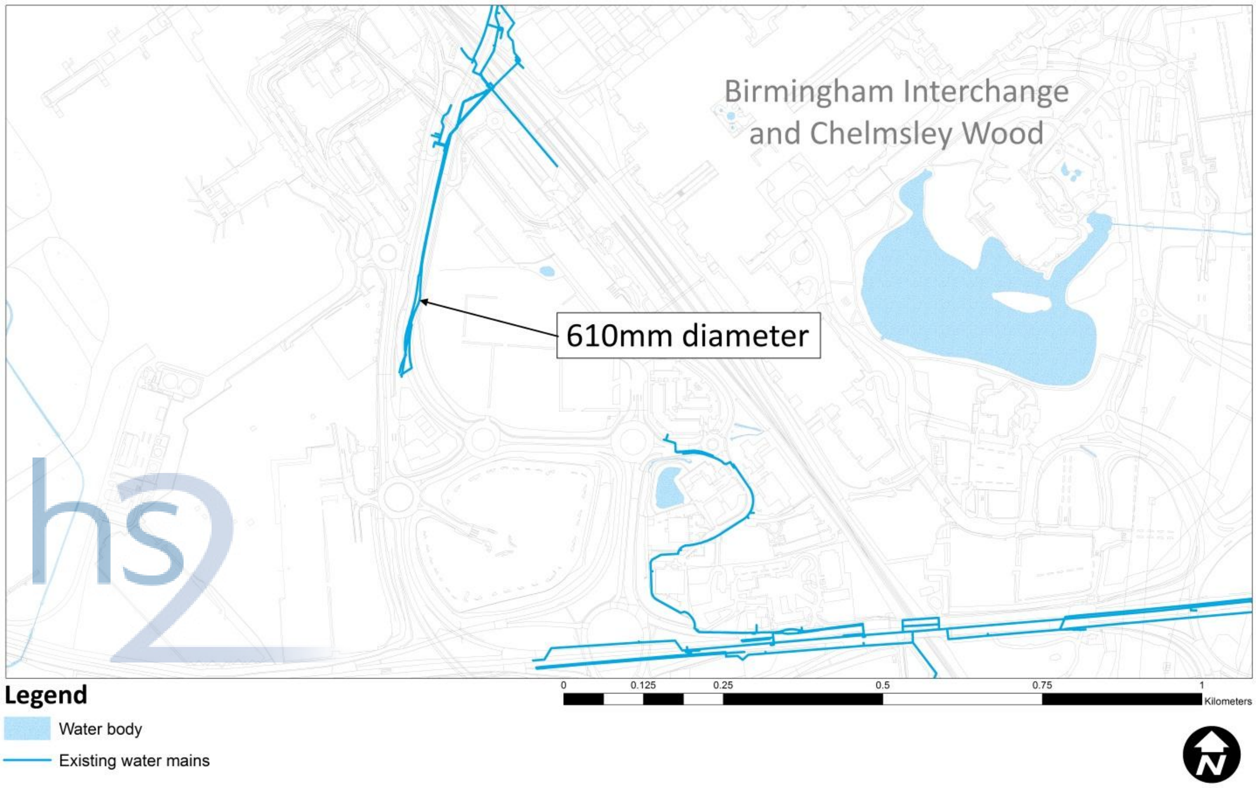


Figure 7: NEC and Birmingham Airport water mains



6.6.6 An assessment of how existing water supply infrastructure interacts with the Proposed Scheme has been undertaken.

Reservoir Failure

6.6.7 The probability of flooding occurring from the failure of a reservoir or large water body created by impoundment of water, by a dam or other retaining structure is extremely low. The Environment Agency's website reports that there has been no loss of life due to reservoir failure in the UK since 1925. All large water bodies across the UK have to be maintained and monitored to a very high standard under the Reservoir Act 1975[22]. This requires regular inspection of any water body designated a reservoir by a nominated engineer. However if a reservoir does fail the impact is likely to be severe and far reaching. It is a requirement of NPPF and The Flood and Water Management Act 2010[23] to evaluate the implications of reservoir failure on all proposed development even if the likelihood is very low. The Flood and Water Management Act 2010 proposes to change the capacity threshold at which reservoirs are regulated from 25,000m^3 to 10,000m^3. Secondary legislation which has yet to be enacted is required to enforce this change.

[22] Reservoir Safety Act, (1975), London, Her Majesty's Stationary Office

[23] The Flood and Water Management Act, (2010), London, Her Majesty's Stationary Office

6.6.8 Although impounded water bodies with a capacity less than 10,000m^3 are not within the Reservoir Safety Act, they may still pose a significant flood risk and such water bodies are discussed in this chapter where appropriate.

6.6.9 The Environment Agency's Reservoir Inundation mapping for the Warwickshire area has been compared to the route within the study area.

6.6.10 There is one water body identified on the Environment Agency's Reservoir Inundation maps as posing a flood risk to the River Blythe catchment in the vicinity of the Proposed Scheme, namely Pendigo Lake.

6.6.11 Pendigo Lake is located approximately 0.6km upstream of the Proposed Scheme and is owned and maintained by the NEC. The lake is constructed on line of the Hollywell Brook and provides attenuation of flows up to the 2% AEP flood event. There is no inundation flooding predicted on the Hollywell Brook downstream of Pendigo Lake but it is conceivable that a breach would result in elevated water levels.

6.6.12 The Environment Agency's Reservoir Inundation flood mapping shows the largest area that might be flooded if a reservoir were to fail. In most areas in vicinity to the River Blythe crossing the extent of inundation would be less extensive than the 1% AEP flood event as identified by the Environment Agency's flood mapping. However, the Environment Agency data provided does not indicate flood depths, flow velocities or the time taken for onset of flooding after a breach takes place. There are other water bodies within the Balsall Common and Hampton-in-Arden area which are identified on the Environment Agency Reservoir Inundation maps that may have the potential to impact on the downstream reaches of the Blythe within this study area - see Volume 5: Appendix WR-003-023 for further details.

6.6.13 The Environment Agency's Reservoir Inundation mapping indicates that in the event of a catastrophic failure of any of the reservoirs in the Blythe catchment the flood waters would flow down the river channels and extend out across the floodplains.

6.6.14 In addition to the water bodies described above there are a number of smaller lakes and ponds which could pose a flood risk to the Proposed Scheme but which are not included in the reservoir mapping.

6.7 Summary of baseline flood risk

Table 8: Summary of baseline flood risk for all sources of flooding within the study area

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
Watercourse	Hollywell Brook	Very high 5% AEP	Birmingham Interchange station	Rail level >1m above 0.1% AEP river flood level.
		High	Birmingham Interchange station - Hollywell Brook underbridge	Soffit of viaduct is >1.0m above 1% AEP plus CC level.
		Low	People mover	Station is located outside of 0.1% AEP flood event.
		Very high 5% AEP	People mover	Rail level >1m above 0.1% AEP river flood level.
		Very high 5% AEP	Diverted A452 Chester Road	Road level elevated above 1% AEP plus CC. Culvert designed to convey flow plus additional freeboard allowance.
Watercourse	Unknown tributary 1 - south of Birmingham Interchange station	High	Proposed Scheme: Track to the south of Birmingham Interchange station (Bickenhill embankment)	Rail level >1m above 0.1% AEP water level. Culvert designed to convey design flow with freeboard allowance.
		Low	People mover	Station located outside of 0.1% AEP flood extent.
		Low	A45 Coventry Road	Road on embankment with carriageway above design flood level.
Watercourse	Unknown tributary 2 - north of Birmingham Interchange station	High	Proposed Scheme: Track to the north of Birmingham Interchange station (Bickenhill cutting)	Rail level >1m above 0.1% AEP water level. Culvert is designed to convey design flow with additional freeboard allowance.
Surface water	A45 Coventry Road	Low	Proposed Scheme	Additional run-off from increased paved areas attenuated to greenfield run-off rates using balancing ponds prior to discharge to minor unnamed watercourse.

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
Surface water	Stonebridge Island	Low	Stonebridge Island and land adjacent to the River Blythe	Additional run-off from increased paved areas attenuated to greenfield run-off rates using balancing ponds prior to discharge to Hollywell Brook and to River Blythe tributary.
Surface water	A452 Chester Road	Low	Land adjacent to theRiver Blythe	Additional run-off from increased paved areas attenuated to greenfield run-off rates using balancing ponds prior to discharge to River Blythe.
Surface water	Birmingham Interchange station	Low	Land adjacent to Hollywell Brook	Additional run-off from increased paved areas attenuated to greenfield run-off rates using balancing ponds prior to discharge to Hollywell Brook and to unnamed minor watercourse.
Surface water	A446 Stonebridge Road/A452 Chester Road roundabout	Low	Birmingham Business Park and NEC complex	Additional run-off from increased paved areas attenuated to greenfield run-off rates using balancing ponds prior to discharge to Birmingham Business Park/NEC drainage network.
Surface water	M42 junction 6	Low	M42 drainage network and Land adjacent to Hollywell Brook	Additional run-off from increased paved areas attenuated to greenfield run-off rates using balancing ponds prior to discharge to motorway network Hollywell Brook.
Surface water	M6 junction 4	Low	M6 drainage network	Additional run-off from increased paved areas attenuated to greenfield run-off rates using balancing ponds prior to discharge to adjacent drainage ditch.
Surface water	Southern M42 road crossing south-east of the Birmingham	Medium	Proposed Scheme	Rail level >1m above flood water level.

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
	Business Park			
Surface water	Northern M42 road crossing west of Brickhill Street Farm	Low	Proposed Scheme	Rail level >1m above flood water level.
Artificial sources:	Pendigo lake	Low Lake not significantly elevated. Risk of breach on outfall.	People mover	Rail level >1m above maximum water level.
		High	M42 and Proposed Scheme	Controlled outflow from Pendigo lake to Hollywell Brook.
Groundwater	Superficial deposits overlying the Mercia Mudstone from Pasture Farm overbridge to the East Way Loop underbridge.	Medium-high High groundwater levels within Secondary A and B aquifers		No historical incidents of groundwater flooding.

7 Flood risk management measures

7.1.1 The purpose of this FRA is to demonstrate that within the study area, the Proposed Scheme can be implemented without putting the proposed infrastructure at risk of flooding or increasing flood risk to third parties. However to do this, mitigation measures have had to be incorporated into the design to either safeguard the Proposed Scheme and associated infrastructure or adjacent land users.

7.1.2 In the first instance the risk of flooding from rivers and streams has been assessed and the water level generated by the 0.1% AEP river flood events has been calculated, with an allowance for blockage of existing culverts and bridges. The rail level will be set a minimum of 1m above this level, or a flood protection structure will be provided.

7.1.3 To do this a number of physical mitigation measures have had to be included in the design to either safeguard adjacent land users or the Proposed Scheme and associated infrastructure. These physical measures are described below.

7.1.4 The Proposed Scheme will require existing Hollywell Brook to be diverted. A new diverted channel has been designed. River hydraulic modelling demonstrates that the changes proposed to the river regime does not increase flood risk throughout the system up to the 1% AEP plus CC event.

7.1.5 Replacement floodplain storage has been provided adjacent to Hollywell Brook.

7.1.6 Where the Proposed Scheme has been assessed as encroaching on existing floodplains, replacement floodplain storage has been proposed on a level for level basis.

7.1.7 Surface water management across the package is being provided to protect the Proposed Scheme up to the 0.1% AEP rainfall event by providing a collection and conveyance system. This system will be connected to attenuation areas that will safeguard third party land by ensuring surface water discharges do not increase up to the 1% AEP plus CC rainfall event.

8 Post-development flood risk assessment

8.1 River flood risk – River Blythe catchment

Stonebridge Island modifications (A45 Coventry Road/A452 Chester/Kenilworth Road)

8.1.2 The Stonebridge Island modifications will include revised filter lanes onto the A45 Coventry Road.

8.1.3 The location is beyond the limits of the River Blythe model created (as part of the work on the Balsall Common and Hampton-in-Arden area) to assess the impact of River Blythe viaduct and the potential flood risk impact has been assessed by comparing the Environment Agency's flood zone mapping with earthwork profiles to determine whether any loss of flood storage and change to flood flows could occur.

8.1.4 The assessment indicates that the earthworks will be generally outside of the floodplain extents even allowing for an additional factor of safety applied to flood levels to account for uncertainty in the derivation of levels. However, part of the existing A452 Kenilworth Road slip road is within the Environment Agency's Flood Zone 3 extent due to a low point in the vertical alignment. There is no significant change to flood risk in this area.

Hollywell Brook

Birmingham interchange station

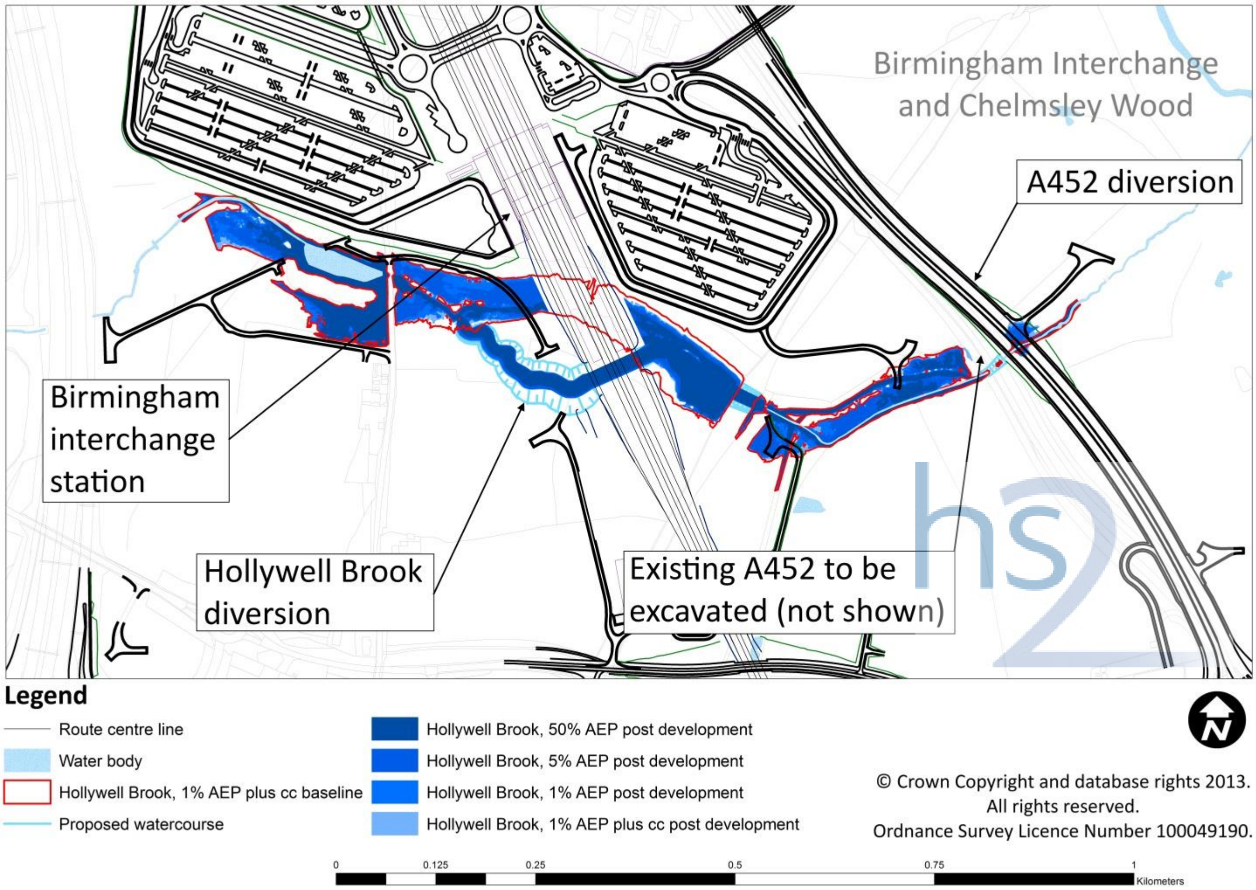
8.1.5 Birmingham Interchange station, car parks, roadways, balancing ponds and People Mover Depot are mainly located outside of the Environment Agency floodplain for the Hollywell Brook, with the exception of the following:

- the southern section of the Birmingham Interchange station platforms and mainline tracks will impact on Hollywell Brook and floodplain. To mitigate these impacts a diverted section of watercourse will be provided with an enhanced out of bank capacity and level for level replacement floodplain storage will be provided; and
- the support structure to the people mover track is located within the Hollywell Brook floodplain. To mitigate the impact, level for level replacement floodplain storage will be provided.

8.1.6 The Proposed Scheme will cross the Hollywell Brook channel and floodplain on the Hollywell Brook underbridge between Middle Bickenhill Lane and the dismantled Hampton-in-Arden to Shustoke line. The Proposed Scheme will cross the watercourse via a 10m bridge structure with a watercourse diversion creating a channel alignment which crosses perpendicular to the Proposed Scheme to shorten the crossing length. The channel diversion will be constructed as a two stage channel designed to, approximately, convey the 50% AEP flow within bank. The channel will be confined within a cutting which slightly narrows the floodplain in comparison to the existing floodplain alignment. The existing channel will be partly retained as a backwater where the development permits.

8.1.7 A plan showing the proposed diversion is shown in Figure 8.

Figure 8: Proposed Hollywell Brook diversion and A452 Chester Road diversion



8.1.8 The Hollywell Brook underbridge and channel diversion has been incorporated into the baseline river hydraulic model of the Hollywell Brook to produce a post development model. The proposed A452 Chester Road diversion is also included. The model also includes the removal of an existing culvert which passes beneath the dismantled Hampton-in-Arden to Shustoke line embankment, downstream of the Hollywell Brook underbridge. It is proposed to remove the culvert beneath the embankment as it could cause a future flood risk to the Proposed Scheme given its age and flow capacity.

8.1.9 The full range of flood events have been simulated within this model to determine the impact caused by the Proposed Scheme on the performance of Hollywell Brook.

8.1.10 The post development flood maps for the 5% AEP and 1% AEP plus CC are included in Maps WR-05 and WR-06 (Volume 5, Map Book Water resources).

8.1.11 The relative changes in water level between the baseline model and the post-development model are presented in Table 9.

Table 9: Hollywell Brook post development flood level comparison (for cross-section locations see Volume 5: Appendix WR-004-018)

	AEP					
Proposed Scheme feature	**50%**	**10%**	**5%**	**2%**	**1%**	**1% plus CC**
Baseline 65m downstream of Middle Bickenhill Lane (model cross-section 17)	85.893	85.989	86.021	86.064	86.092	86.137
Post development upstream of channel diversion 65m downstream of Middle Bickenhill Lane (model cross section 17)	85.833	85.93	85.966	86.011	86.047	86.091
Change	-0.06	-0.059	-0.055	-0.053	-0.045	-0.046
Baseline ~60m downstream of Proposed Scheme (model cross-section 12)	85.003	85.23	85.333	85.486	85.625	85.825
Post Development downstream of Proposed Scheme (model cross-section 12)	84.991	85.116	85.163	85.227	85.281	85.351
Change	-0.012	-0.114	-0.17	-0.259	-0.344	-0.474

8.1.12 The flood levels indicate a small decrease in flood levels upstream of the proposed diversion (and the Proposed Scheme) for the 1% AEP plus climate change event. More frequent events show a decrease in flood levels by up to 63mm due to the increased conveyance of the channel diversion and the removal of the downstream dismantled Hampton-in-Arden to Shustoke embankment restriction. Optimisation of the channel diversion design should enable the conveyance to be reduced if required.

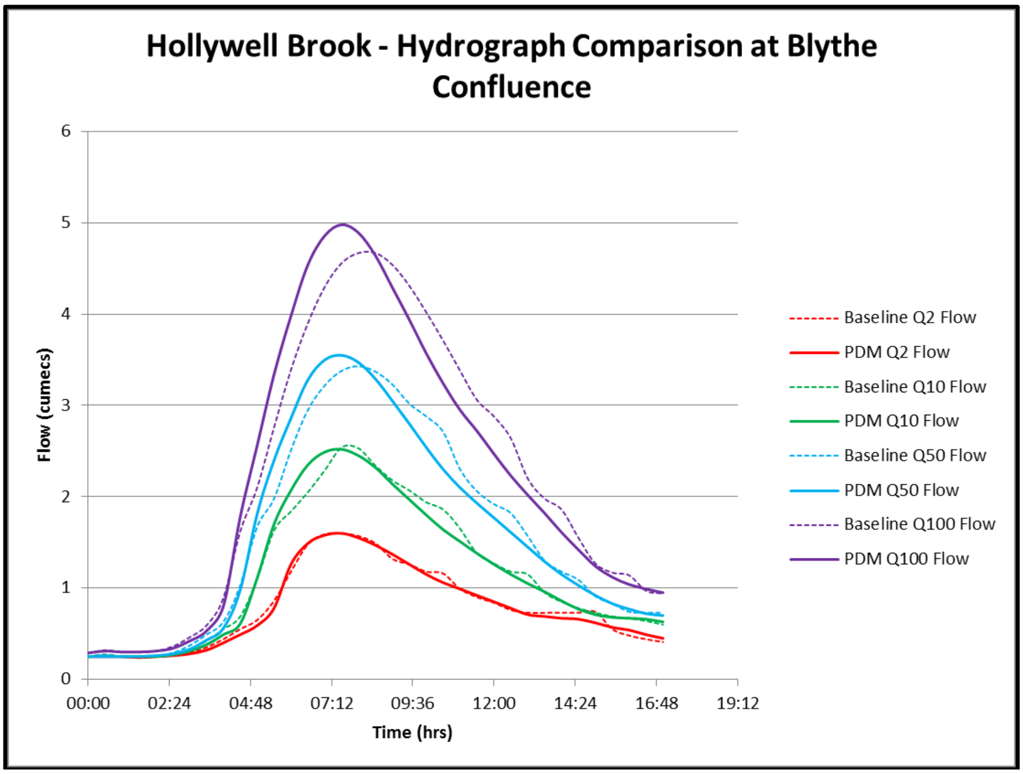
8.1.13 The culvert beneath the dismantled Hampton-in-Arden to Shustoke line causes a significant flow restriction and will artificially raise flood levels in the vicinity of the Proposed Scheme crossing. With the culvert and embankment removed the resulting flood level upstream of the dismantled Hampton-in-Arden to Shustoke line culvert shows a decrease of up to 480mm for the 1% AEP plus climate change event.

8.1.14 In addition, the 1D models were run in an unsteady (time dependent) state to provide an initial assessment of the potential downstream impacts associated with the removal of the railway embankment. The approach was not documented in the accompanying modelling report in Volume 5: Appendix WR-004-018, but a single storm duration hydrograph was generated for selected return periods. The duration is based on the ReFH recommended storm duration. Figure 9 identifies the comparative change in flow at the confluence with the River Blythe.

8.1.15 For the 1% AEP plus climate change flow there is a predicted 6% ($0.3m^3/s$) increase in downstream flows in Hollywell Brook as a result of the removal of the railway culvert and embankment. The increase in flood flow in the River Blythe is equal to approximately 0.5% of 1% AEP plus CC flow and is unlikely to cause a significant impact on flood levels in the river.

8.1.16 Notwithstanding the above it is noted that further development of the hydraulic model is required to assess the potential impact on downstream flows in order to demonstrate that flood risk is not increased to an unacceptable level. Alternative options for managing flood risk would involve replacement of the culvert beneath the dismantled Hampton-in-Arden to Shustoke line and localised lowering of the embankment profile to enable overtopping at less frequent flood events. This will also manage both flood risk to the Proposed Scheme and downstream receptors.

Figure 9: Baseline and post development hydrographs for Hollywell Brook



8.1.17 The increase in flood flows is predicted to increase flood levels by up to 30mm downstream of the existing A452 Chester Road culvert.

8.1.18 Flood protection to the Proposed Scheme is assessed in relation to the 0.1% AEP. The top of rail of the Proposed Scheme is approximately 90.66m AOD, 4m above the estimated 0.1% AEP flood level of 86.652m which includes simulated blockage of the downstream bridge and Proposed Scheme viaduct.

8.1.19 The Proposed Scheme will result in a reduction in floodplain storage due to the embankment encroaching on the 1% AEP plus CC floodplain. The 1D modelling approach adopted for this crossing cannot accurately take account of modelling floodplain storage; however, an area of replacement floodplain storage is proposed to be located adjacent to the watercourse on a level for level basis which provides storage in combination with the storage available within the channel diversion.

A452 Chester Road diversion crossing

8.1.20 The proposed A452 Chester Road diversion will cross the Hollywell Brook channel and floodplain. The road diversion will cross the watercourse via a 4m span, 45m long culvert structure, which will replace the existing A452 Chester Road twin culverts which are approximately 4.6m in span. The hydraulic analysis indicates that a slightly smaller culvert span can be utilised while not reducing upstream flood levels due to the location of the new culvert downstream of the existing crossing.

8.1.21 The proposed culvert has been incorporated into the baseline river hydraulic model of the Hollywell Brook to produce a post development model. The full range of flood events have been simulated within this model to determine the impact caused by the Proposed Scheme on the performance of the Hollywell Brook.

8.1.22 The post development model flood maps for the 5% AEP and 1% plus CC AEP are shown in Maps WR-05 and WR-06 (Volume 5, Map Book Water).

8.1.23 The relative changes in water level between the baseline model and the post development model are presented in Table 10.

Table 10: Hollywell Brook post development flood level comparison at A452 Chester Road crossing

	AEP					
Proposed Scheme Feature	50%	10%	5%	2%	1%	1% plus CC
Baseline - approximately 70m upstream of the A452 Chester Road (model cross-section 7)	83.761mAOD	83.933 mAOD	84.001 mAOD	84.096 mAOD	84.182 mAOD	84.288 mAOD
Post development upstream of channel diversion (model cross-section 7)	83.7 mAOD	83.808 mAOD	83.86 mAOD	83.938 mAOD	84.01 mAOD	84.106 mAOD
Change (m)	-0.061	-0.125	-0.141	-0.158	-0.172	-0.182

8.1.24 The mapping and flood levels indicate a decrease in flood levels upstream of the proposed diversion for events up to 1% AEP plus CC as shown in Table 10. The reduction in upstream flood levels is as a result of the relocation of the culvert and at a lower elevation. The decrease in flood levels extends approximately 140m upstream of the existing A452 Chester Road. The proposed culvert dimensions will not result in a significant increase in pass forward flow; therefore there will not be an increase in flood risk to the River Blythe directly resulting from the revised culvert.

8.1.25 The Proposed Scheme will result in a reduction of floodplain storage as a result of the new A452 Chester Road embankment encroaching on the 1% AEP plus CC floodplain. The 1D modelling approach adopted for this crossing cannot accurately model floodplain storage, however, an area of replacement floodplain storage is proposed to be located adjacent to the watercourse on a level for level basis, see Map CT-06 (Volume 2, CFA24 Map Book).

People mover

8.1.26 The people mover will link the proposed Birmingham Interchange station to the NEC, Birmingham International station and Birmingham Airport. The proposed people mover will be an elevated viaduct on structural columns at approximately 25m spacing. The people mover has not been incorporated into the post-development model of the Hollywell Brook but the circular piers/proposed spacing will have a negligible impact on flood levels provided piers are positioned away from the watercourse. Replacement floodplain storage may be required to account for loss of floodplain storage although small localised excavations will be sufficient to compensate for the loss of storage.

Other tributaries

Post development assessment method

8.1.27 The proposed development assessment for the two small tributaries has been undertaken using the method described in CIRIA Report C689.

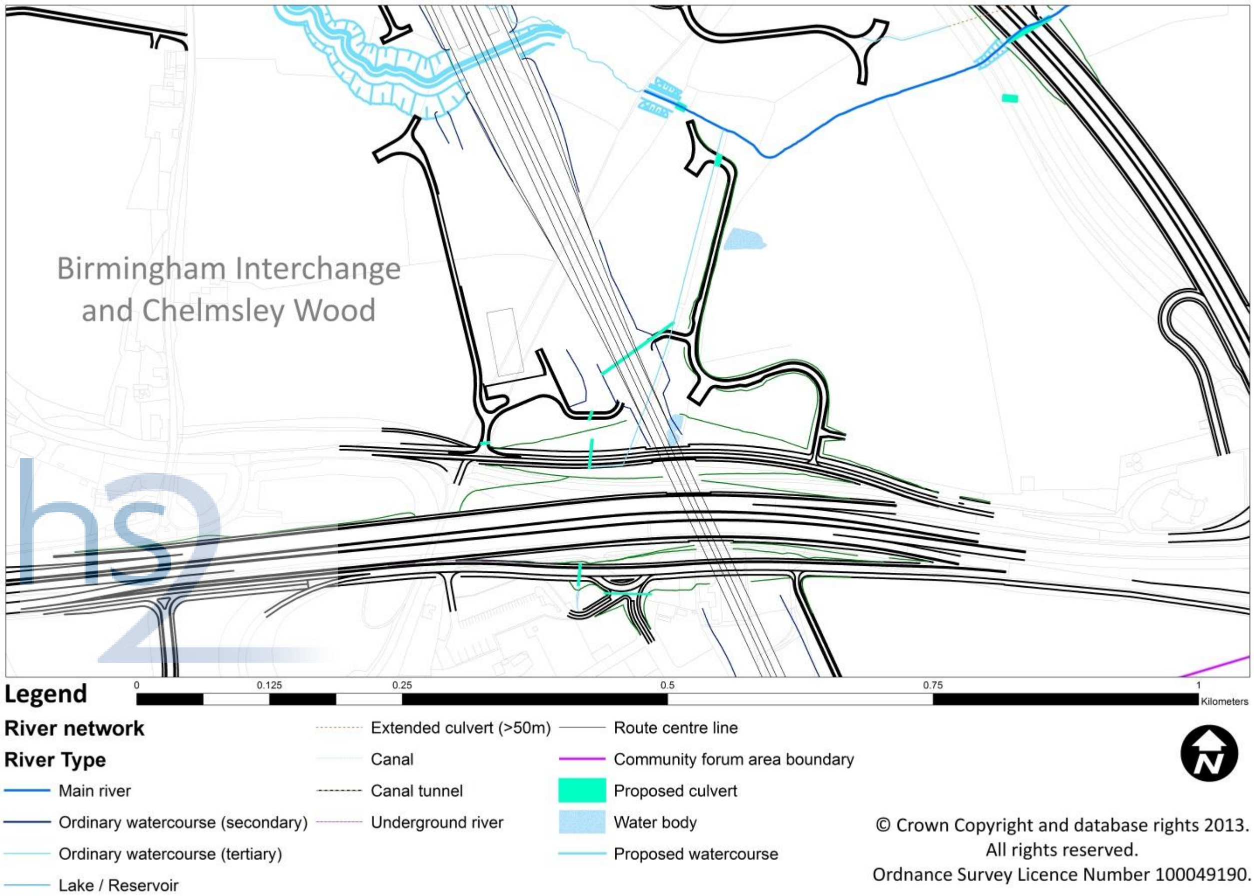
8.1.28 The approach calculates the culvert dimension required to convey the 1% AEP flood flow including a 30% allowance for climate change. The culvert is designed to convey the flood flow while maintaining a minimum 600mm freeboard to soffit. By providing a culvert sufficiently sized to convey the 1% AEP flood flow the impact on upstream flood level increases is controlled.

8.1.29 The culvert method does not take account of a backwater affect from downstream structures. The method is used to primarily assess the conveyance capacity of the culvert

8.1.30 No allowance has been made for the installation of trash screens or security gratings on culverts.

8.1.31 The predicted upstream flood level derived using the culvert assessment methods are shown below along with a description of the development proposals.

Figure 10: Watercourse crossing to Hollywell Brook

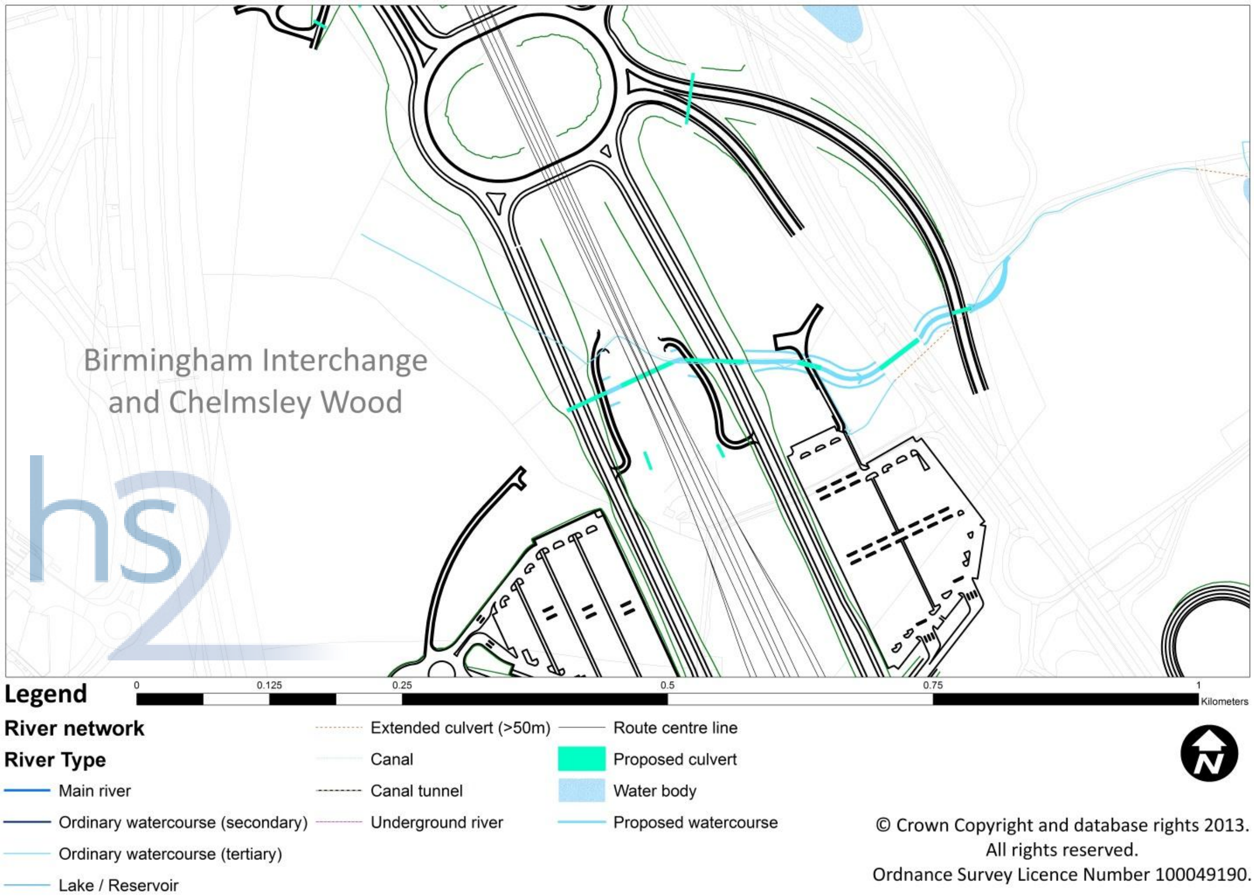


8.1.32 This unnamed watercourse will be crossed by the Proposed Scheme at approximately 45 degrees to the channel direction. The proposed culvert will involve an upstream channel diversion to enable the culvert to cross perpendicular to the Proposed Scheme. There is an existing culvert located upstream of the Proposed Scheme crossing which passes beneath the A45 Coventry Road alignment.

8.1.33 A 1.8m span by 1.8m deep box culvert is proposed to convey the watercourse beneath the Proposed Scheme. The resultant upstream flood level is predicted to be 87.8mAOD. A drop inlet structure and re-grading of the downstream channel will be required to provide sufficient protection to the Proposed Scheme. In comparison the upstream A45 Coventry Road is at an elevation of 95m and the development upstream of the A45 Coventry Road is also well above the predicted flood level.

8.1.34 The upstream A45 Coventry Road culvert is to be extended on both the upstream and downstream sides to accommodate new service roads. The proposed extension will be sized sufficiently to not increase upstream flood levels by increasing the dimensions over and above the existing culvert dimensions.

Figure 11: Watercourse crossing to Denbigh Spinney



8.1.35 This unnamed watercourse will be crossed by the route at five separate locations within a 500m reach. The five separate crossings of this watercourse by proposed development, the Proposed Scheme, two interchange access roads, a new A452 link road and a service road to provide access to drainage balancing ponds. There is an existing culvert located downstream of the Proposed Scheme crossing which carries the watercourse beneath the A446 Stonebridge Road/A452 Chester Road junction and dismantled Hampton-in-Arden to Shustoke line embankment.

8.1.36 A 1.5m span by 1.5m deep box culvert is proposed to convey the watercourse at each crossing. Significant re-grading and diversion of the drain will be required to the alignment due to the extent of development infrastructure.

8.2 Surface water and sewerage flood risk

Proposed Scheme drainage

8.2.2 Surface water run-off from within the new railway corridor will be attenuated to balance peak run-off rates and volumes to pre-development levels for a range of return periods up to the 1% AEP (+30% allowance for climate change). Based on the available information at this time and due to high groundwater levels, it is deemed unlikely that infiltration techniques will be a viable method of surface water disposal in this section of the route, therefore within the study area all the Proposed Scheme rail drainage systems will discharge to watercourses.

8.2.3 Drainage interception and conveyance designs will utilise a combination of piped track drainage and open channels which will convey drainage flows to balancing ponds while protecting the Proposed Scheme from flooding up to the 0.1% AEP year storm event.

8.2.4 Ponds are the preferred method of flow attenuation due to the linear nature of the project and the requirement to control run-off at managed discharge points (design drawings are shown in Map CT-06 (Volume 2, CFA24 Map Book).

8.2.5 The Proposed Scheme drainage catchments are listed in Table 11 and shown in Annex A of this report.

Table 11: Railway drainage catchments and outfalls

Linear km of route drained	Receiving watercourse	Watercourse status	Greenfield peak discharge rate Q100 (l/s/ha)*	Outfall Number
0.780	Hollywell Brook	Main river	2.60 - 12.55	O-1562
0.820	Hollywell Brook	Main river	2.60 - 12.55	O-1566
1.120	Unnamed	Ordinary	2.60 - 12.55	O-1573

Notes: *Greenfield peak discharge Q100 rate is derived from QBAR estimation for rural catchments, IoH 124. Attenuation volumes have been provisionally sized on the lower value and further site investigation will be required to confirm actual discharge rates at the detailed design stage.

Highway drainage

8.2.6 Throughout the study area, the Proposed Scheme requires the diversion or replacement of a number of existing public highways. The associated highway drainage systems will be reconfigured or replaced.

8.2.7 Drainage of reconfigured highways will aim to replicate the existing highway drainage strategy and outfalls. Where the paved area of the highway has been increased, highway run-off will be collected from an area equivalent to the additional paved surface and attenuated to balance peak run-off rates and volumes to pre-development levels for a range of flood events up to 1% AEP (+30% allowance for climate change). It is unlikely that infiltration techniques will be a viable method of surface water disposal in this section of the route.

8.2.8 Balancing ponds are the preferred method of flow attenuation due to the linear nature of the project and the requirement to control run-off at managed discharge points (design drawings are shown in Map CT-06 (Volume 2, CFA24 Map Book).

8.2.9 The highway drainage catchments are listed in Table 12 and shown in Annex A of this report.

Table 12: Highway drainage catchments and outfalls

Existing area of highway drained (ha)	Proposed area of highway drained (ha)	Net change in highway drained (ha)	Receiving watercourse	Greenfield peak discharge rate Q100 (l/s/ha)*	Outfall number
	1.274	+1.274	Unnamed	2.91 - 12.55	O-1560
1.329	1.928	+0.599	Hollywell Brook	2.60 - 12.55	O-1562
	0.571	+0.571	Unnamed watercourse	7.79 - 12.55	O-1567
	0.256	+0.256	M42 to Hollywell Brook	14.54	O-1561
	0.256	+0.256	Unnamed watercourse	14.54	O-1562
3.838	3.927	+0.089	Unnamed	-	O-1572
	0.971	+0.971	Unnamed	3.50 - 12.55	O-1575
	0.754	+0.754	Unnamed	6.14 - 12.55	O-1581
2.143	-	-	Unnamed	-	O-1585

*Greenfield peak discharge Q100 rate is derived from QBAR estimation for rural catchments, IoH 124. Attenuation volumes have been provisionally sized on the lower value and further site investigation will be required to confirm actual discharge rates at the detailed design stage.

Birmingham Interchange station and people mover

8.2.10 Surface water from Birmingham Interchange station roofs, associated car parks and roadways will discharge through a below ground piped gravity drainage system into a series of attenuation ponds and outfalls via control structures into the Hollywell Brook. Surface water from the northern car parks and northern half of the south west car park will discharge through a below ground piped gravity drainage system into balancing ponds and outfall via control structures into the unnamed watercourse north of Park Farm.

8.2.11 The route will be in cutting through the station area requiring separate east and west side drainage systems.

8.2.12 Discharges from the station drainage systems into Hollywell Brook have been designed to be restricted to a provisional equivalent green field run-off rate of 2 l/s/ha for storm events up to the 1% AEP plus a 30% allowance for climate change. A more accurate assessment of the discharge rate may be undertaken during detailed design stage.

8.2.13 From a review of Ordnance Survey maps and topographic data, surface water run-off from neighbouring areas will not pose a flood risk to Birmingham Interchange station development site as its location on the higher ground between the southern and northern catchments and the station concourse will be at an elevated level of 102mAOD, which is approximately 3m above the general surrounding areas.

8.2.14 All surface water run-off generated from Birmingham Interchange station, car parks and roadways will be managed by new drainage infrastructure. The closest building is Park Farm (see Map CT-06-106, Volume 2, CFA24 Map Book) which is protected by the station exit slip road onto the A452 Chester Road. This exit slip road is in cutting to allow it to pass beneath the A452 Chester Road and will direct any run-off away from the Birmingham Interchange station and east car park way from the Park Farm.

Table 13: Birmingham Interchange station drainage catchments and outfalls

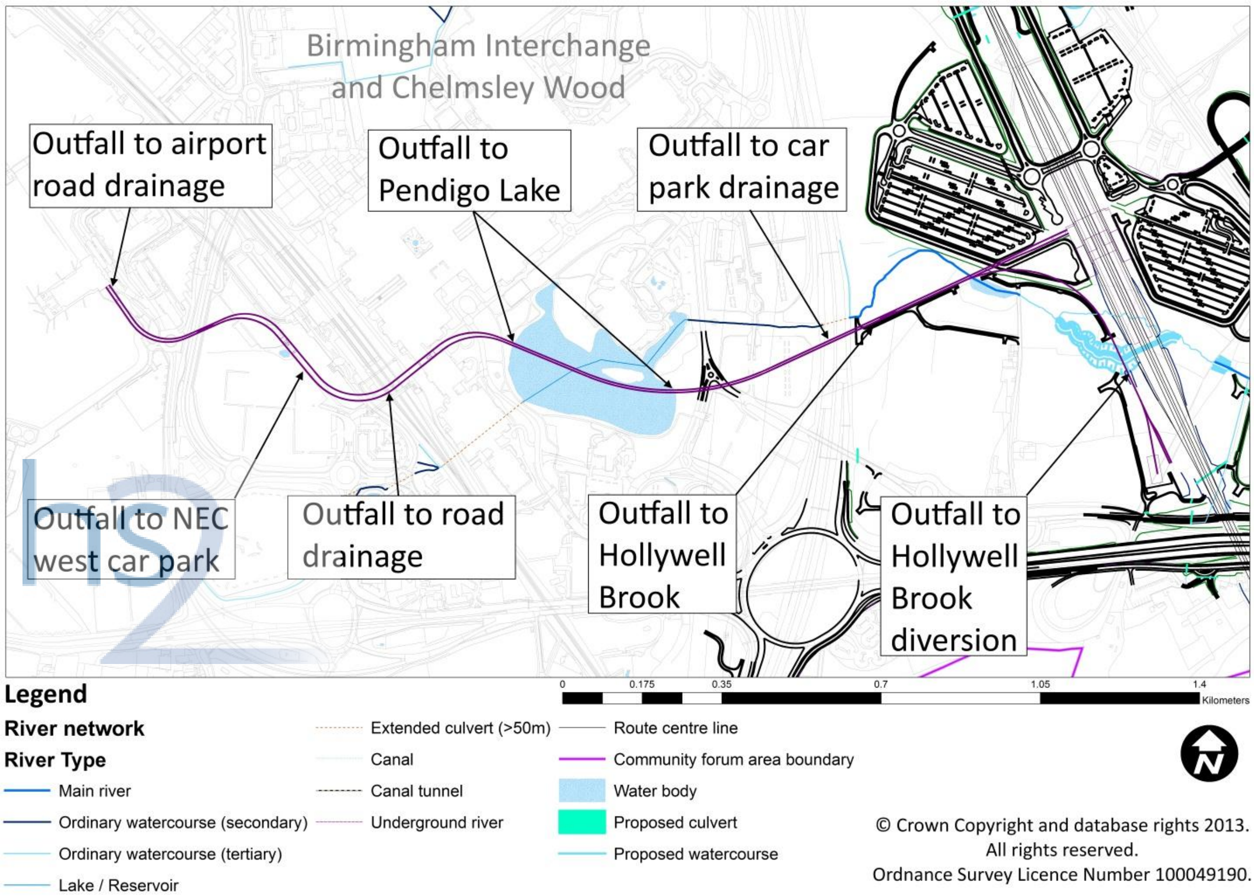
Drainage catchment type	**Drainage catchment area (ha)**	**Receiving watercourse**	**Watercourse status**	**Attenuated volume (m^3)**	**1% peak discharge rate (l/s)**	**Outfall**
Car park	3.46	Hollywell Brook	Main	3390	9.3	Southwest
Soft landscape	1.31					
Buildings	0.44					
Carriageway	1.99	Hollywell Brook	Main	8700	19.7	Southeast
Car park	2.75					
Soft landscape	1.41					
Concourse	0.56					
Buildings	0.44					
Carriageway	1.31	Un-named watercourse	Ordinary	8400	20.9	Northwest
Concourse	0.45					
Car park	6.77					
Soft landscape	1.90					

Car park	2.48	Un-named watercourse	Ordinary	2400	7.3	Northeast
Soft landscape	0.42					
Carriageway	0.77					

People mover

8.2.15 The people mover will link the proposed Birmingham Interchange station to the NEC, Birmingham International station and Birmingham Airport. The people mover will be an elevated viaduct on structural columns; the concrete slab for the viaduct is approximately 9.5m wide, which allows for two way movements and an evacuation and maintenance footway on either each side.

Figure 12: People mover layout



8.2.16 Where the people mover spans existing drained catchments no additional attenuation or surface water management is proposed beyond connection into the existing drainage infrastructure for a given catchment.

8.2.17 The people mover will be on an elevated viaduct with the support columns at approximately 25m centres (increased spans will be provided to cross some existing features). These will affect the following hydraulic features:

- approximately 10 support columns will be located within Pendigo Lake, but the overall volume lost due to the columns is considered to be negligible compared with the capacity of Pendigo Lake; and
- support columns to the people mover viaduct will be located within the Hollywell Brook floodplain. To mitigate the impact, level by level replacement floodplain storage will be provided for the loss of floodplain.

8.2.18 The elevated viaduct will be drained by trapped gullies into a collector pipe system hung from the viaduct and discharging at support columns to below ground outfalls.

8.2.19 Appropriate pollution control measures will be provided at outfalls to Pendigo Lake and Hollywell Brook.

8.2.20 The people mover drainage outfall strategy will be as follows:

- where the people mover is routed over agricultural land within the Birmingham Interchange station triangle, flows will discharge to balancing ponds with controlled outfalls, restricted to the provisional equivalent green field run-off rate of 2 l/s/Ha for storm events up to the 1% AEP (plus a 30% allowance for climate change;
- where the people mover is routed above aprons, roads, buildings, hard standings and existing ponds, there will be minimal increase in existing catchment areas and the people mover will discharge into the existing systems un-attenuated; and
- where the people mover is routed above the porous NEC west car park the people mover will discharge to new soakaways.

Surface water flow catchments

8.2.21 The Proposed Scheme introduces a continuous linear feature that will potentially interrupt and divert existing drainage catchments and surface water flow paths.

8.2.22 Where the Proposed Scheme is on embankment or in cutting (including retained cutting) and the adjacent land falls towards the Proposed Scheme (or there are existing urban drainage systems that may divert flows towards the route), a cut off drainage system and threshold protection measures will be provided to intercept the flows from external catchments and divert them to the nearest crossing point of the route, typically a bridge or culvert conveying a watercourse under the route.

8.2.23 Intercepted flows in the Birmingham Interchange and Chelmsley Wood area will be conveyed via grass lined ditches to outfall to a watercourse at a location as close to existing flow path as possible. The grass lined ditch will be graded to provide slow time of travel, so that time of entry to the watercourse will not be increased significantly, minimising any effect on the watercourse.

8.2.24 The design assesses catchments and surface water flow paths in the baseline and post-development case to ensure there will be no increase in flood risk to adjacent properties and receptors upstream or downstream of the Proposed Scheme.

8.2.25 An initial assessment of surface water flow catchments which will be modified as a result of the Proposed Scheme are shown in the figures presented in Annex A of this report. Where catchment flow paths are intersected by the Proposed Scheme, the design, where possible, will replicate existing catchment distributions and minimise alterations to surface water flow paths from their existing routes. Where this is not possible, a safe and secure route for drainage systems and surface water flows has been identified such that there will be no increased flood risk to properties or businesses. Flows will be intercepted using cut-off ditches and conveyed to a suitable outfall location as indicated on the Map CT-06 (Volume 2, CFA24 Map Book).

8.2.26 Within north Chelmsley Wood, as a conservative approach, the highest level of surface water flood risk was taken and therefore the route centreline will be at medium risk, with areas within 1km of the route being at high risk from surface water. The Proposed Scheme has the potential to interrupt surface water flow which could result in an increased flood risk in surrounding areas. The Proposed Scheme will alter the permeability of the ground and has the potential to increase surface water runoff rates and hence the associated flood risk. This section of route will be located on ground with a higher elevation than areas to the east and west. Therefore, it will be considered that any surface water flow routes will generally be away from the route at this location and hence the Proposed Scheme will not have a significant impact on flow routes. The proposed drainage system will be designed to attenuate peak surface water runoff from the Proposed Scheme such that it is no greater than the existing current day runoff during the 1% AEP rainfall event. The design will also ensure that the flood level does not exceed 1m from the track level during the 0.1%AEP rainfall event.

8.2.27 Catchments with notable issues are described in more detail in the following sections.

Sub-catchment 6B

8.2.28 Flow paths which will cross the line of the Proposed Scheme will be intercepted by a cut-off ditch and conveyed northwards to outfall to Hollywell Brook approximately 300m upstream of existing with negligible impact due to relatively small catchment area.

Sub-catchment 7A

8.2.29 Surface water flows in catchment between the M42, Proposed Scheme and proposed A452 Chester Road diversion will be collected in cut-off ditches and conveyed to an unnamed watercourse. This will be similar to existing flow paths with negligible impacts to the existing surface water regime.

Sub-catchment 7B

8.2.30 Surface water flows in the catchment between the Proposed Scheme and the proposed A452 Chester Road diversion will be collected in cut-off ditches and conveyed to an unnamed watercourse. This will be discharged at a similar location to the existing flow paths with negligible impacts to the existing surface water regime.

8.3 Groundwater

8.3.1 It is assumed that the principal mechanism, by which Proposed Scheme will increase groundwater flood risk, is where impermeable structures (e.g. lined tunnels and pile walls) act as a barrier to groundwater flow and have the potential to cause a rise in groundwater level with mounding in the vicinity of these structures. Other changes to the groundwater environment such as through drained cuttings are not assumed to increase the groundwater flood risk as the drainage design will take account of groundwater flows entering the cutting.

8.3.2 To assess the possible changes to groundwater levels and flows, and the associated change in groundwater flood risk, a high level assessment of the groundwater conditions along the route has been undertaken to understand where the Proposed Scheme is likely to interact with groundwater (i.e. it is on an aquifer and within the proximity of groundwater levels). These areas have the potential to increase relative groundwater flood risk, although further assessment of the proposed design and structures is made to confirm whether a change in groundwater flood risk is likely. Further field data collection and analytical or numerical modelling is then recommended to quantify this change.

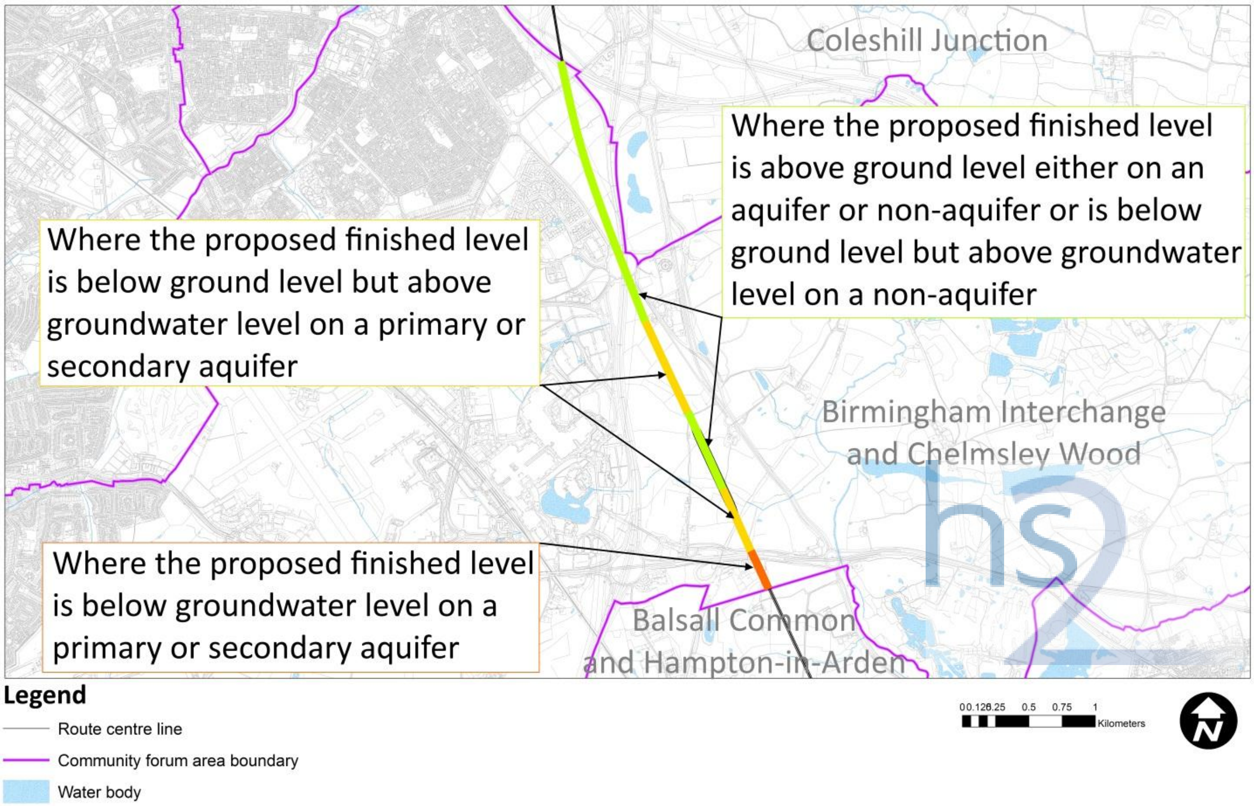
8.3.3 Table 14 shows the criteria used to identify areas where changes to the level of groundwater flood risk along the route corridor may occur from the introduction of the Proposed Scheme.

Table 14: Criteria to identify areas where changes to groundwater flood risk may occur

Low	Where the proposed finished level is above ground level either on an aquifer or non-aquifer or is below ground level but above groundwater level on a non-aquifer
Medium	Where the proposed finished level is below ground level but above groundwater level on a primary or secondary aquifer
High	Where the proposed finished level is below groundwater level on a primary or secondary aquifer

8.3.4 Information presented in Table 15, and summarised in Figure 13 below, illustrate the areas within the study area where there is greater potential for changes to groundwater flood risk across post development both to the development and elsewhere.

Figure 13: Areas of greater potential for changes to groundwater flood risk within the study area



8.3.5 The main areas where groundwater flood risk may be increased is where the Proposed Scheme is within an aquifer and below groundwater level, and even then it depends on the nature of the infrastructure and how much of a barrier to groundwater flow it will create.

8.3.6 One main section has been identified as being below assumed groundwater level within the aquifer. Between the Pasture Farm overbridge and the east way loop bridge the route cuts through the top of the Mercia Mudstone, the top weathered zone can sometimes be water bearing and water strikes have been recorded in local borehole logs. However the Proposed Scheme does not include any significant impermeable barriers to groundwater flow, pile foundations for the bridges are proposed, which will not significantly change the groundwater flood risk.

Table 15: Summary of the conditions along the route corridor and areas where the groundwater flood risk may change

Approximate grid reference	Title	Existing Ground Level (mOD)	Proposed level (mOD)	Assumed groundwater level(mOD)	Aquifer Classification (Superficial)	Aquifer Classification (Solid Geology)	Superficial Geology	Solid Geology (approximate depth, m) at reference borehole	Reference borehole	Distance to reference borehole BH (m)	Assumed ground level (mOD) at reference borehole	Assumed depth to groundwater level (m) at reference borehole
SP2094 8249	Pasture Farm overbridge	98.8	90.5	97.8	Secondary A	Secondary B	Glaciofluvial deposits (sand/gravel)	Mercia Mudstone (3)	SP28SW327	120	98.5	1
SP2081 8291	A45 Service Road overbridge	96.5	89.8	92.5	-	Secondary B	absent	Mercia Mudstone (0)	SP28SW341	150	96	4
SP2079 8295	A45 Coventry Road overbridge	96.6	89.8	92.6	-	Secondary B	absent	Mercia Mudstone (0)	SP28SW341	150	97	4
SP2079 8295	East Way Loop underbridge	96.6	89.8	92.6	-	Secondary B	absent	Mercia Mudstone (0.5)	SP28SW341	100	87.5	4
SP2077 8314	East Way overbridge	91.6	89.6	87.6	-	Secondary B	absent	Mercia Mudstone (0.5)	SP28SW341	150	89	4
SP2055 8357	Enlarging of M42 junction 6 roundabout	90.3	90.2	-	-	-	-	-	-	-	-	-
SP2042 8385	Hollywell Brook underbridge	87.1	90.7	watercourse level	Secondary A	Secondary B	absent, though close to Alluvium	Mercia Mudstone (0)	Geol. map only		87	watercourse level

Approximate grid reference	Title	Existing Ground Level (mOD)	Proposed level (mOD)	Assumed groundwater level(mOD)	Aquifer Classification (Superficial)	Aquifer Classification (Solid Geology)	Superficial Geology	Solid Geology (approximate depth, m) at reference borehole	Reference borehole	Distance to reference borehole BH (m)	Assumed ground level (mOD) at reference borehole	Assumed depth to groundwater level (m) at reference borehole
SP2039 8392	Birmingham Interchange station	86.3	90.8	watercourse level	Secondary A	Secondary B	Alluvium local to stream course only approx. 50m wide. Sand and gravel in north area (quarrying proposed)	Mercia Mudstone (5 - 10m in gravel area)	SP28SW320 SP28SW321	400	-	watercourse level
SP2024 8429	People mover	87.3	91.2	-	Secondary A	Secondary B/A	Alluvium local to stream courses. Sand and gravel north of 1567 up to 5m thick. Locally minor outcrops of Head/Glacial till (gravelly sandy clays)	Mercia Mudstone; Arden Sandstone (0 - 5 locally)	SP18NE75	-	-	-
SP2010 8453	Station access road over A452 Chester Road	93.2	91.4	90.2	Secondary A	Secondary B	Glaciofluvial deposits (sand/gravel)	Mercia Mudstone (5)	SP28SW320	120	98.5	3
SP2031 8416	A452 Chester Road bridge over A446 Stonebridge Road	97.8	97.9	-	Secondary A	Secondary B	Glaciofluvial deposits (sand/gravel)	Mercia Mudstone (unknown)	Geol. map only			-

Approximate grid reference	Title	Existing Ground Level (mOD)	Proposed level (mOD)	Assumed groundwater level(mOD)	Aquifer Classification (Superficial)	Aquifer Classification (Solid Geology)	Superficial Geology	Solid Geology (approximate depth, m) at reference borehole	Reference borehole	Distance to reference borehole BH (m)	Assumed ground level (mOD) at reference borehole	Assumed depth to groundwater level (m) at reference borehole
SP1967 8549	A446 Stonebridge Road /A452 Chester Road roundabout south bridge	99.6	98.9	-	Secondary A	Secondary B	Glaciofluvial deposits (sand/gravel), over a thin layer of Till.	Mercia Mudstone (3)	SP18SE81	300	99	-
SP1964 8555	A446 Stonebridge Road/A452 Chester Road roundabout north bridge	99.6	100.5	-	Secondary A	Secondary B	Glaciofluvial deposits (sand/gravel), over a thin layer of Till.	Mercia Mudstone (6)	SP18SE81	300	99	-
SP1951 8573	A446 Link Road over M42	101.7	103.8	-	-	Secondary B	-	Mercia Mudstone	-	-	-	-
SP1945 8582	M42 underbridge	100	105.9	97	Secondary A	Secondary B	Glacio deposits (sand and gravel)	Mercia Mudstone (6)	A452-A446-9	0	96-98	3

Artificial sources/infrastructure failure

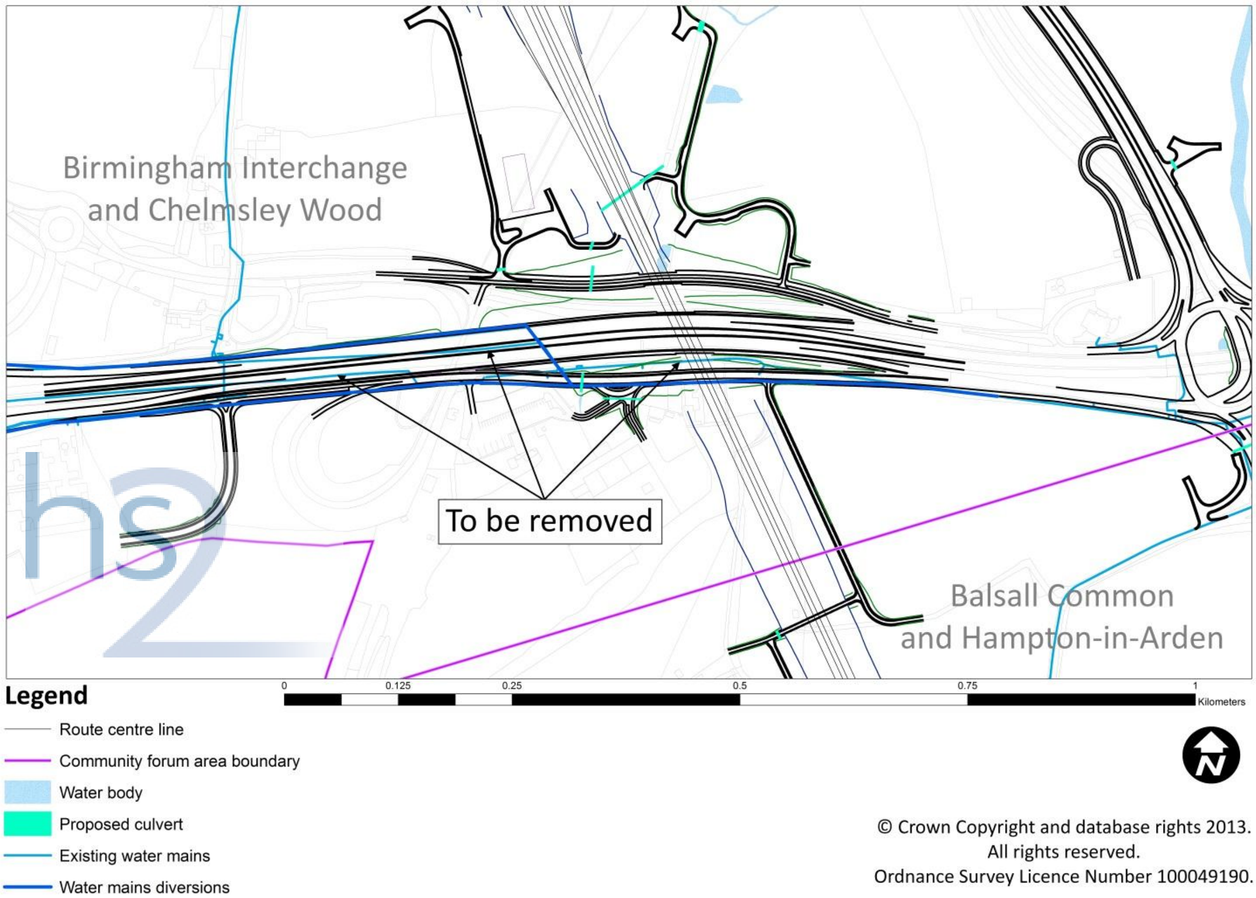
8.3.7 Overland flow has been adopted as a term in this section to distinguish it from surface water flooding i.e. where the capacity of the drainage system is exceeded. Overland flow in this section refers to flow over the surface which is caused by infrastructure failure.

Water supply network

8.3.8 Assets are mapped and where appropriate the potential overland flow paths inspected by interrogation of topographic data. The extent of overland flow from a pipe failure will depend on discharge rate which is in turn influenced by a number of factors including water main diameter, pressure, depth and upstream water source. Given the limited data available and complexity in accurately assessing overland flow routes this FRA is limited to identification of potential flow paths only.

8.3.9 Where existing or diverted water mains and water distribution infrastructure have been judged to offer a potential source of flood risk from an upstream catchment an assessment of potential surface water flow routes have been made of the risk associated with this source.

Figure 14: Coventry Road diversion



8.3.10 The existing water mains in the A45 Coventry Road will be diverted within the new bridge alongside existing locations where affected by the highway works from Stonebridge Island to junction 6 of the M42. Diverted pipes within the verges will replace those in the central reserve. Local topography suggests that in the event of failure, water would be collected to the existing field drainage ultimately discharging to Hollywell Brook and the River Blythe.

8.3.11 Where the route will pass under the A45 Coventry Road there is a small risk of water reaching Proposed Scheme in the event of failure, though the fall of the carriageway along with the carriageway drainage will convey surface waters away from the cutting. The recycling depot remains at risk of flooding in the event of failure overwhelming the carriageway drainage system; however the existing box culvert would continue to convey run-off under the A45 Coventry Road to Hollywell Brook in this event.

8.3.12 No diversion is proposed to the NEC and Birmingham Airport water main and therefore no change in risk is envisaged where the NEC people mover is elevated.

Reservoirs/large water bodies

8.3.13 The proposed overland flow routes associated with reservoir failure have been compared to the Proposed Scheme. The overland flow routes are discussed in the following sections in relation to the reservoir sources and the Proposed Scheme.

Pendigo Lake

8.3.14 The flood pathway from Pendigo Lake would convey water along the Hollywell Brook and beneath the route. The reservoir failure plot does not indicate a flood extent on the Hollywell Brook indicating that the extent of inundation to the brook would not significantly increase water levels to the extent that results in out of bank flow.

8.3.15 Further assessment is recommended in the form of a review of the asset owner's reservoir emergency plan which may contain more accurate assessment of downstream flood risk and proposals for flood warnings.

8.4 Summary of potential impacts on flood risk

8.4.1 Reference should be made to the flood maps provided in Volume 5: Map book WR-05. A summary of main receptors is provided in Table 16.

Table 16: Summary of potential flood risk impacts within the study area

Receptor	Vulnerability	Pathway	Impacts
General Proposed Scheme		River	Significant changes in hydraulics and loss of floodplain storage at Hollywell Brook.
		Surface water	Proposed Scheme protected from surface water flow paths by cut-off ditches. Surface water drainage network designed to maintain 0.1% AEP water level with a minimum of 1m freeboard to rail level.
		Groundwater	No significant effects on flood risk due to groundwater have been identified within this assessment. Although the Proposed Scheme is in

Receptor	Vulnerability	Pathway	Impacts
			cutting through the Birmingham Interchange station area, groundwater seepage will be intercepted within the track drainage network.
		Drainage Systems	No significant flood risk effects to the Proposed Scheme due to drainage systems have been identified within this assessment.
		Artificial Bodies	Pendigo lake outfalls to Hollywell Brook upstream of the Proposed Scheme's viaduct. The soffit of the viaduct is >1m above the design flood level.
Land adjacent to Hollywell Brook	Less vulnerable	Hollywell Brook	People mover piers are within Pendigo lake. These slightly decrease available storage within the lake. This will potentially result in a very small increase to flow within the brook and to downstream receiving watercourses.
Land adjacent to Hollywell Brook	Less vulnerable	Hollywell Brook	Removal of the dismantled Hampton-in-Arden line embankment and culvert will remove existing constriction/blockage therefore increasing downstream flows.
Stonebridge roundabout adjacent to the River Blythe	More vulnerable	River Blythe and surrounding land	Localised changes to flood extents and levels
	More vulnerable	Adjacent land	Surface water run-off from increased paved areas to be attenuated to greenfield run-off prior to discharge.
Birmingham Business Park	Less vulnerable	Drainage system	Surface water run-off discharge to existing drainage network to be attenuated and controlled to greenfield run-off rates.
M42 drainage	Essential infrastructure	Drainage system	Surface water run-off from increased surface area around junction 6 of M42 to be attenuated and controlled before discharging to motorway network.
M6 drainage	Essential infrastructure	Drainage system	Surface water drainage from increased junction paved areas to be attenuated and outfall to drainage ditches separate to motorway track.
Superficial deposits overlying the Mercia Mudstone from Pasture Farm overbridge to the East Way Loop underbridge	Less vulnerable	Groundwater	Proposed scheme is below groundwater levels (Diddington cutting). This will be mitigated by drainage systems.

9 Conclusions

9.1.1 This FRA accounts for the flood risk considerations caused by construction of the Proposed Scheme within the study area, both to the Proposed Scheme and third parties.

9.1.2 In order to fully understand the existing risk posed by the river catchment and to be able to evaluate the impact of the Proposed Scheme on the hydraulic behaviour of the River Blythe catchment a 1D steady state model (HEC-RAS) was created for Hollywell Brook. The Environment Agency does not have an existing model of the Blythe catchment.

9.1.3 Within the study area the only model constructed was for Hollywell Brook as this was the only watercourse crossing where the 1% AEP+CC exceeded $3m^3/s$. Simplified culvert calculations based on CIRIA Report C689 were used to assess the post development flood risk impact of smaller watercourses.

9.1.4 The Proposed Scheme has been incorporated into the existing baseline river models in order for the impact of the proposals on flood risk to be determined.

9.1.5 The Proposed Scheme will be designed to be resilient up to and including the 0.1% AEP storm event. This will be achieved by either setting the rail level at 1m above the 0.1% AEP flood level or by protecting the route using flood defence structures set at a level that is equivalent to 300mm above the 0.1% return AEP flood level.

9.1.6 A diversion of Hollywell Brook will be necessary to accommodate the proposed Birmingham Interchange station platforms. The channel design and route alignment ensures no increase in water levels up or downstream and replacement floodplain storage volume will be created close to the diverted channel to ensure this. River hydraulic modelling of this makes sure this change to the river regime will not increase flood risk throughout the system.

9.1.7 The surface water management strategy for this study area ensures run-off generated by rain water falling onto the Proposed Scheme is collected, attenuated and discharged at a controlled rate. The strategy is designed to manage discharges generated by rain storm events with a 1% AEP plus a 30% increase in rainfall intensity to allow for changes in rainfall patterns due to climate change.

10 References

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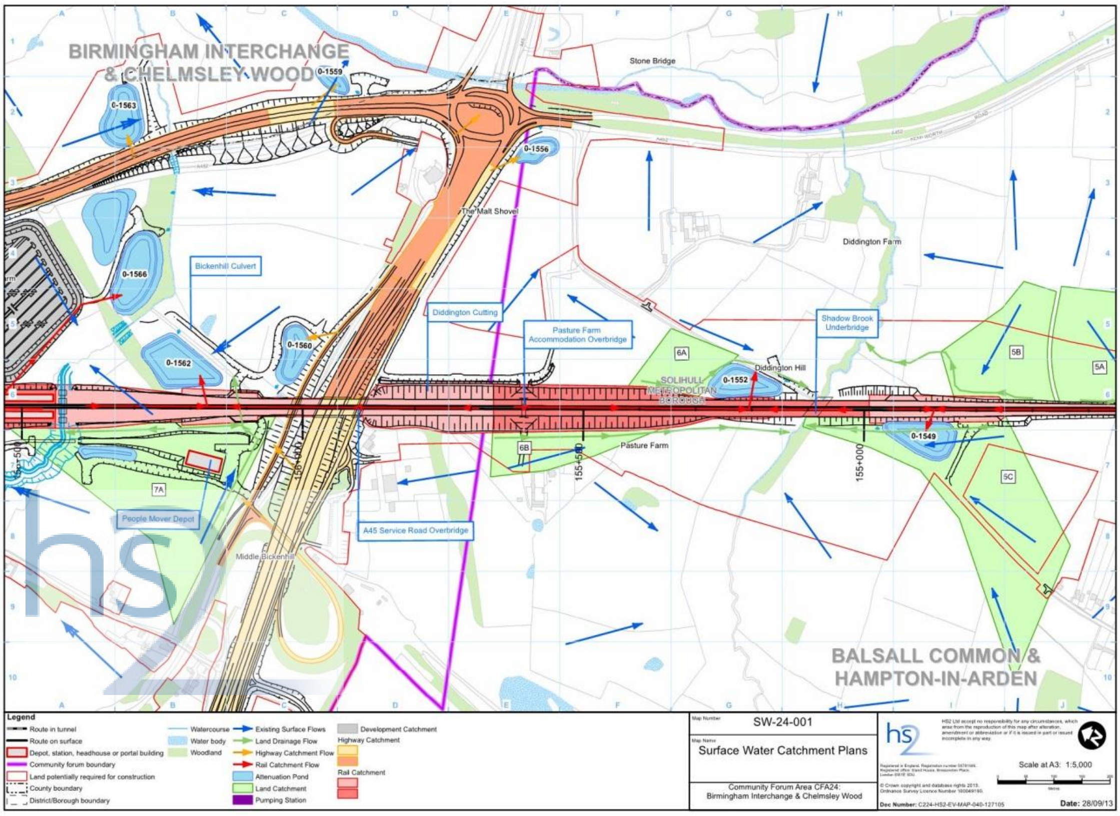
11 Annex A

11.1 Surface water catchment flow figures


BIRMINGHAM INTERCHANGE & CHELMSLEY WOOD
BALSALL COMMON & HAMPTON-IN-ARDEN
Stone Bridge
The Malt Shovel
Diddington Farm
Bickenhill Culvert
Diddington Cutting
Pasture Farm Accommodation Overbridge
Shadow Brook Underbridge
Diddington Hill
Pasture Farm
People Mover Depot
A45 Service Road Overbridge
Middle Bickenhill
SW-24-001
Surface Water Catchment Plans
Community Forum Area CFA24: Birmingham Interchange & Chelmsley Wood
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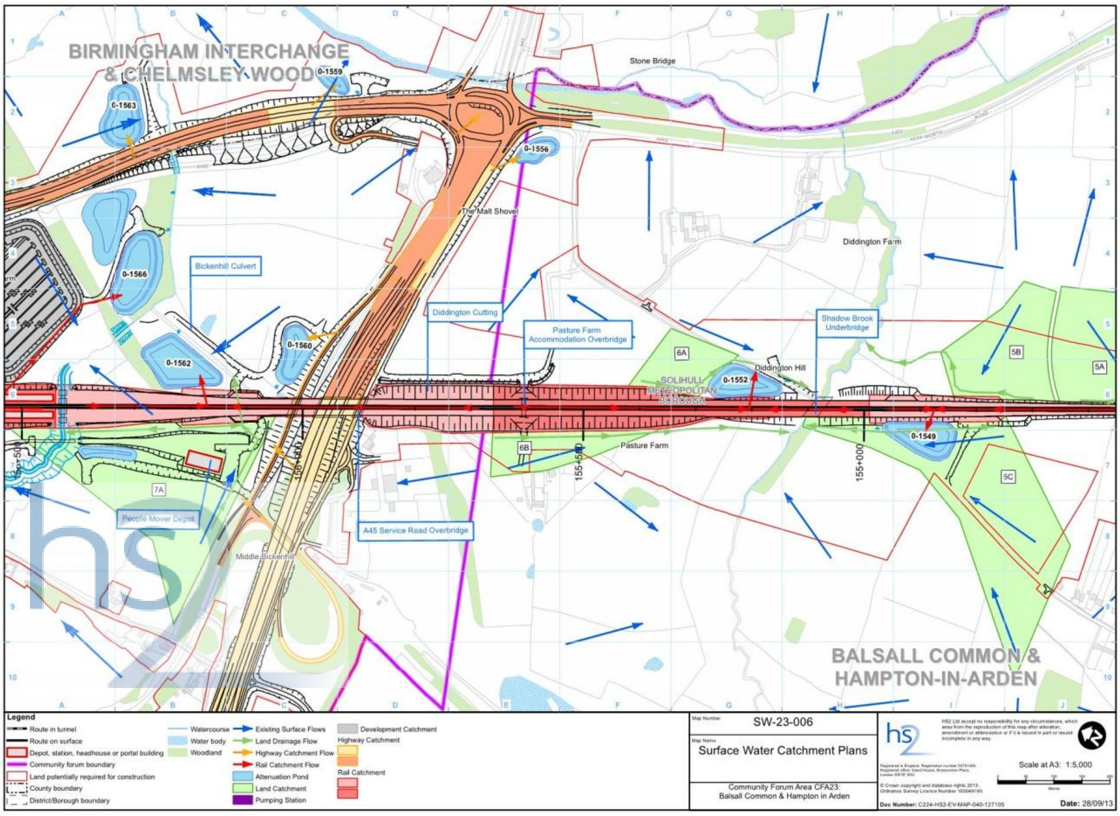
Date: 28/09/13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Pasture Farm Accommodation Overbridge
Shadow Brook Underbridge
Diddington Hill
Pasture Farm
People Mover Depot
A45 Service Road Overbridge
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SW-23-006
Surface Water Catchment Plans
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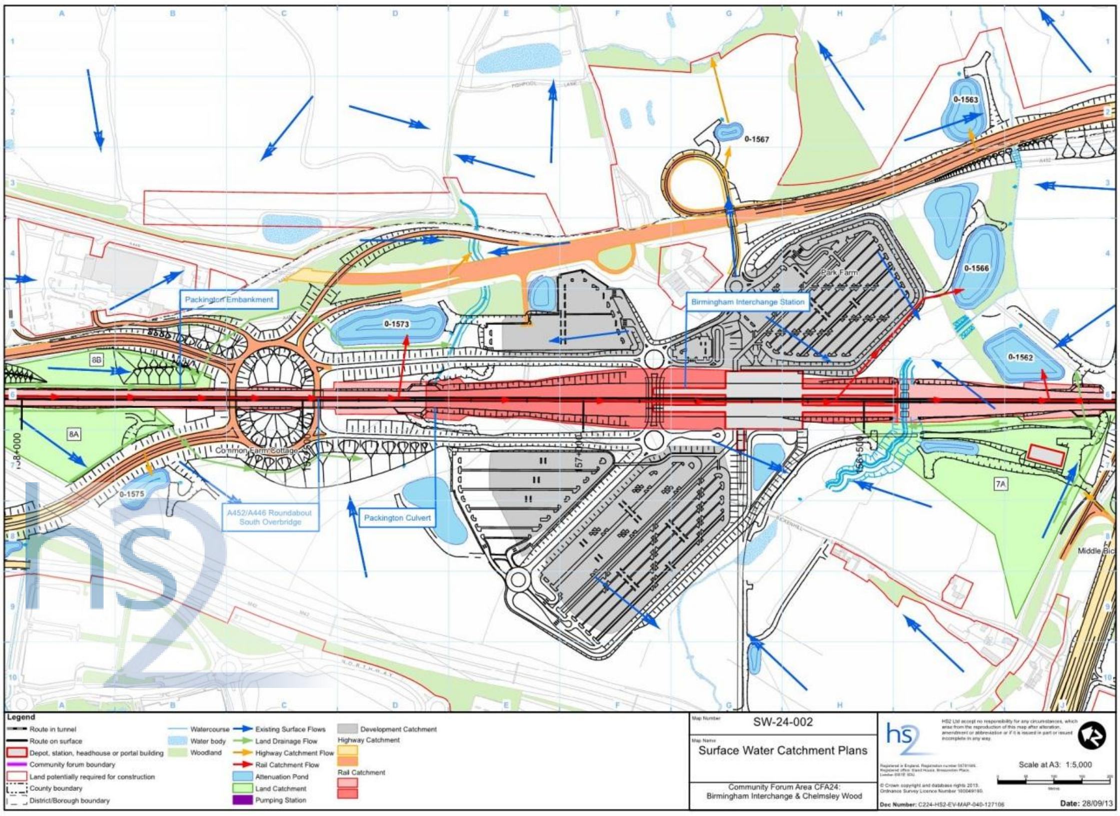

Packington Embankment
Birmingham Interchange Station
0-1563
0-1567
0-1566
0-1573
0-1562
0-1575
A452/A446 Roundabout South Overbridge
Packington Culvert
Common Farm Cottages
8B
8A
7A
Middle Bick
Legend
Route in tunnel
Route on surface
Depot, station, headhouse or portal building
Community forum boundary
Land potentially required for construction
County boundary
District/Borough boundary
Watercourse
Water body
Woodland
Existing Surface Flows
Land Drainage Flow
Highway Catchment Flow
Rail Catchment Flow
Attenuation Pond
Land Catchment
Pumping Station
Development Catchment
Highway Catchment
Rail Catchment
SW-24-002
Surface Water Catchment Plans
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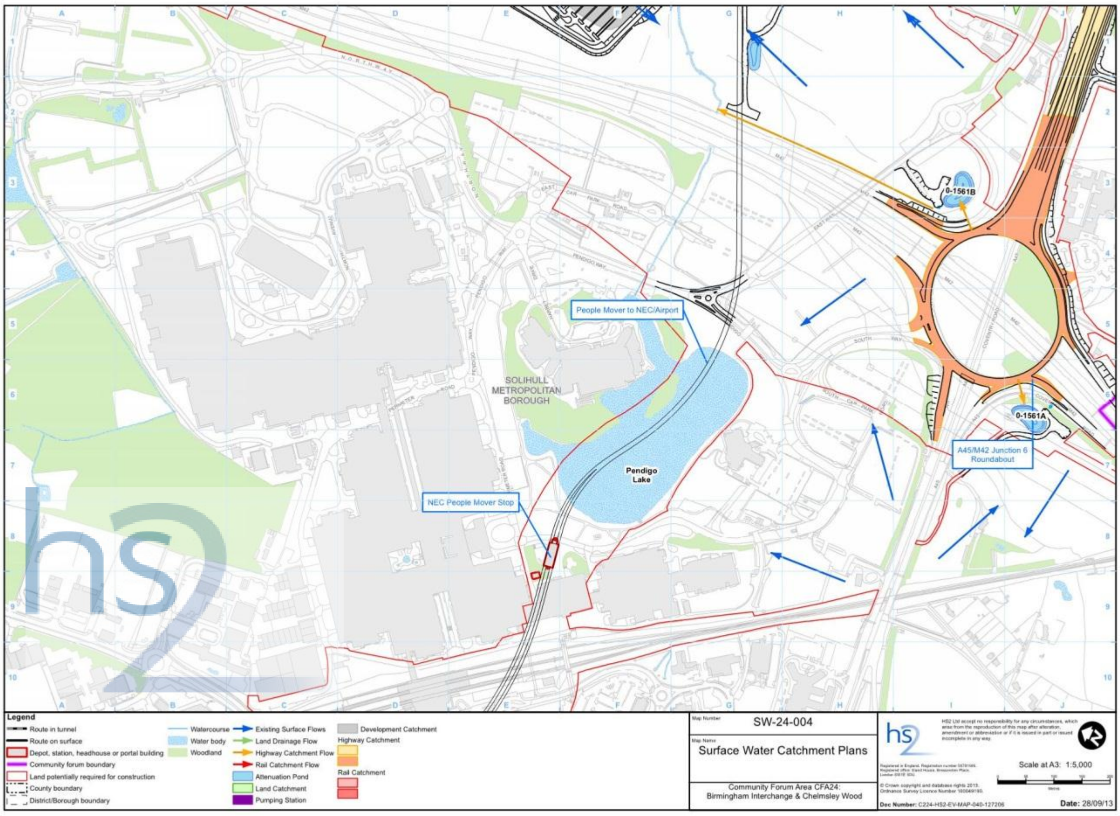

0-1561B
0-1561A
People Mover to NEC/Airport
SOLIHULL METROPOLITAN BOROUGH
Pendigo Lake
NEC People Mover Stop
A45/M42 Junction 6 Roundabout
Legend
Route in tunnel
Route on surface
Depot, station, headhouse or portal building
Community forum boundary
Land potentially required for construction
County boundary
District/Borough boundary
Watercourse
Water body
Woodland
Existing Surface Flows
Land Drainage Flow
Highway Catchment Flow
Rail Catchment Flow
Attenuation Pond
Land Catchment
Pumping Station
Development Catchment
Highway Catchment
Rail Catchment
SW-24-004
Surface Water Catchment Plans
Community Forum Area CFA24: Birmingham Interchange & Chelmsley Wood
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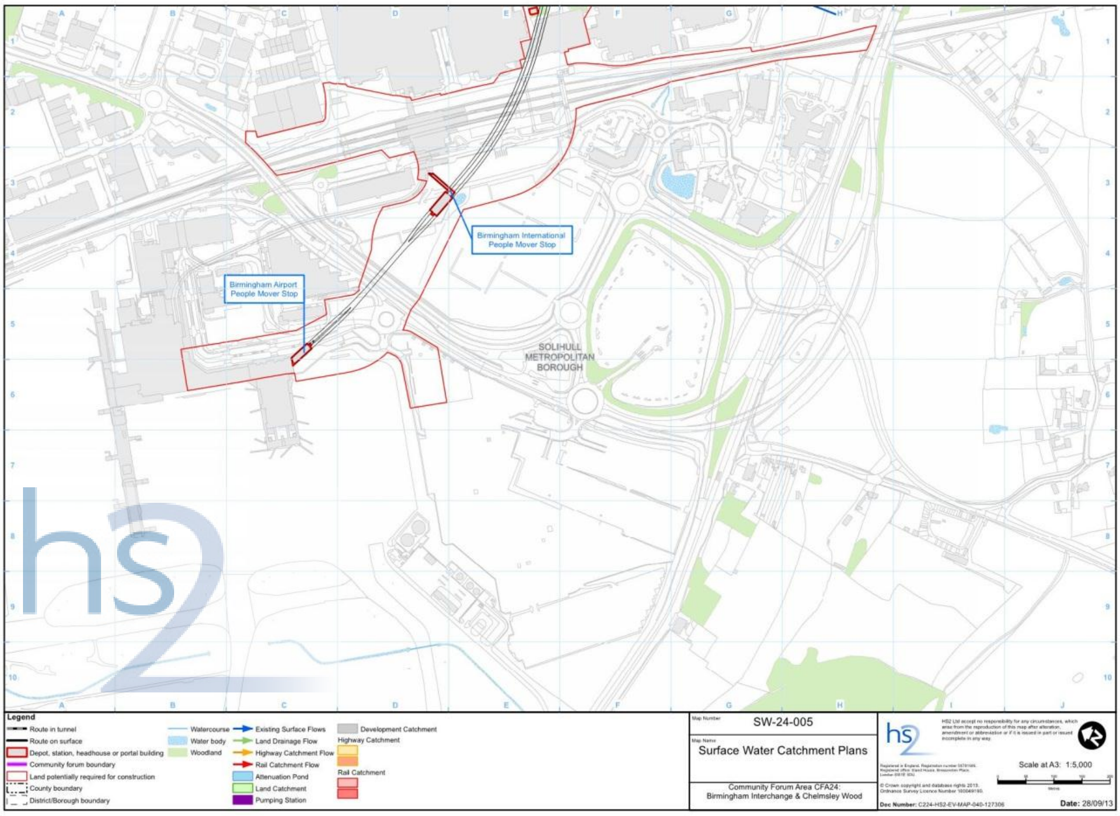
Birmingham International People Mover Stop
Birmingham Airport People Mover Stop
SOLIHULL METROPOLITAN BOROUGH
Legend
Route in tunnel
Route on surface
Depot, station, headhouse or portal building
Community forum boundary
Land potentially required for construction
County boundary
District/Borough boundary
Watercourse
Water body
Woodland
Existing Surface Flows
Land Drainage Flow
Highway Catchment Flow
Rail Catchment Flow
Attenuation Pond
Land Catchment
Pumping Station
Development Catchment
Highway Catchment
Rail Catchment
SW-24-005
Surface Water Catchment Plans
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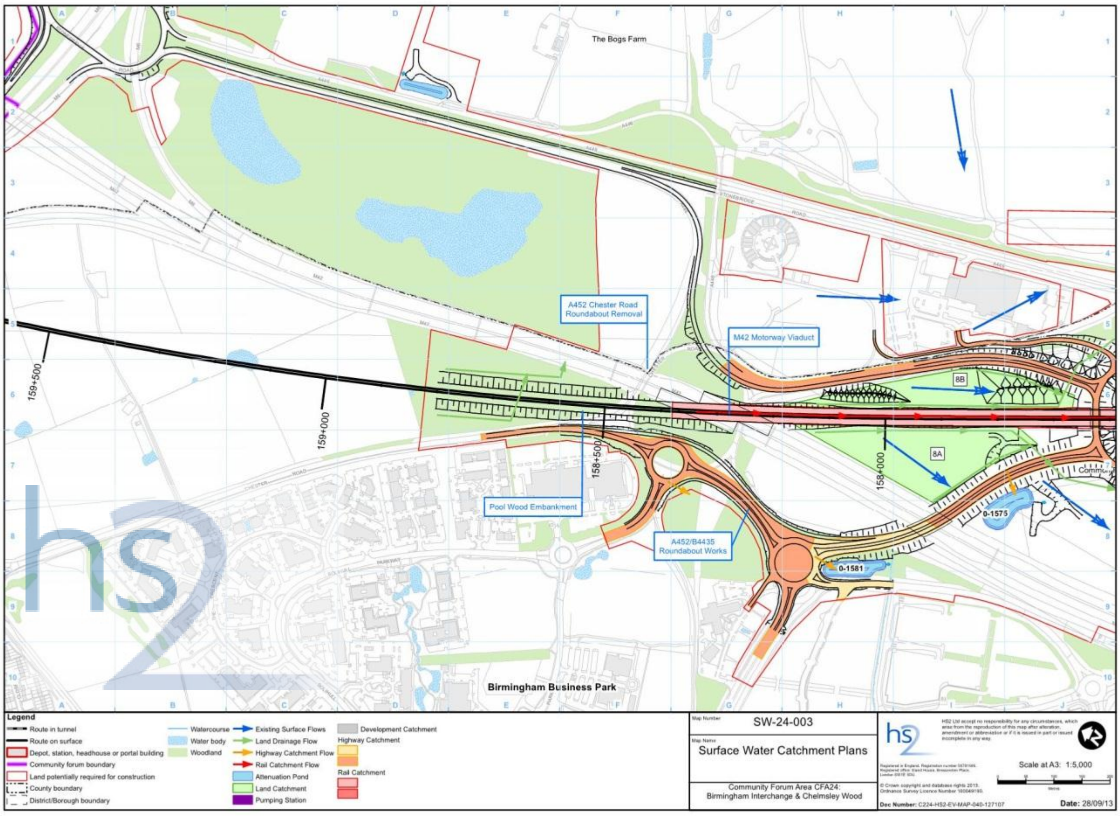
Date: 28/09/13


The Bogs Farm
A452 Chester Road Roundabout Removal
M42 Motorway Viaduct
159+500
159+000
158+500
158+000
8B
8A
0-1575
0-1581
Pool Wood Embankment
A452/B4438 Roundabout Works
Birmingham Business Park
Legend
Route in tunnel
Route on surface
Depot, station, headhouse or portal building
Community forum boundary
Land potentially required for construction
County boundary
District/Borough boundary
Watercourse
Water body
Woodland
Existing Surface Flows
Land Drainage Flow
Highway Catchment Flow
Rail Catchment Flow
Attenuation Pond
Land Catchment
Pumping Station
Development Catchment
Highway Catchment
Rail Catchment
SW-24-003
Surface Water Catchment Plans
Community Forum Area CFA24:
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